Foreword

by Jean-Christophe NIEL

ASN Director-General

In July 2005, number 165 of *Contrôle* magazine was devoted to the management of radioactive waste in France. It was an opportunity for the various stakeholders involved to have their say, nearly 15 years after the 30th December 1991 Act, known as the "Bataille Act", and a few months prior to the Parliamentary debate of a radioactive waste management bill taking account of scientific and technical knowledge progress and which was to lead to the Act of 28th June 2006. That issue also came out on the eve of the public debate held from September 2005 to January 2006 on the subject of radioactive waste management, more particularly high and intermediate level, long-lived waste, with the aim both of informing the public, but also giving them an opportunity to express their opinion on this topic.

Six years later, many changes have taken place in the field of radioactive waste management. First of all, at a legislative level, planning Act 2006-739 of 28th June 2006 on the sustainable management of radioactive materials and waste, following on from the considerable work done jointly with the French Parliamentary Office for the evaluation of scientific and technological choices, confirmed the areas of research and set a new time-frame. Act 2006-686 of 13th June 2006 on transparency and security in the nuclear field confirmed ASN's role as regulator of nuclear installations. It also set up the High Commission for transparency and information on nuclear safety, which plays an essential role in this field with regard to waste management.

Concerning the projects for disposal of high and intermediate level, long-lived waste, or low-level long-lived waste, the process to identify sites continues, even if the road ahead is today still a long one. Much has been learned from the progress made, in particular in the public sector, thus demonstrating the decisive role of the consultation process, but also the complexity and fundamental nature of the research aimed at ensuring the greatest possible safety and security.

Finally, in recent years, two versions of the National radioactive materials and waste management plan (PNGMDR) have been drafted. This tool was created more than ten years ago, at the initiative of ASN, which worked closely on it with the Directorate General for the Energy and the Climate. The PNGMDR is today essential in providing a clear strategy and roadmap for management of all radioactive materials and waste. Together with the set of legal texts already mentioned and a dedicated radioactive waste agency (ANDRA), the PNGMDR constitutes the third pillar of the French radioactive waste management system.

The past six years have already seen a number of major steps and the next few years will also be marked by significant milestones: organisation of the public debate prior to submission of the authorisation application for a deep geological repository for high and intermediate level long-lived waste, then the review procedure for the repository creation application; resumption of research into siting of the low-level long-lived waste repository; continued work by the pluralistic group in charge of drafting the PNGMDR, taking full advantage of the feedback from implementation of the previous plans.

Finally, the proposed directive for radioactive waste and spent fuel management, adopted in early November 2010 by the European Commission, made this subject one of the priority Community projects. ASN considers this to be a very real step forward and has been heavily involved in the preparatory work. The discussions now under way should lead to the adoption of a directive within the next few months, thus giving the Member States a common framework enhancing the provisions of the nuclear safety directive adopted in 2009.

As borne out by the presentation of the advances made in recent years, the conditions in which radioactive waste is managed are therefore in many respects very different from the situation in 2005. There is however one constant factor in this constantly changing picture: now as six years ago, radioactive waste management remains the principal area of concern for the French population when talking about nuclear power. ASN therefore strives to adapt its actions to these particular concerns and, alongside the other stakeholders involved, is helping to provide the population with accurate information about radioactive waste management, but is also devoting the greatest possible attention to measures that could be taken to improve participation by the bodies representing civil society.

Contrôle presents the issues linked to the management of radioactive waste and the roles of the various stakeholders. Its aim is to give an opportunity to the various stakeholders to freely express their viewpoints on this subject, whether the scientific and technical side, or the more social aspects.

Finally, I would like to welcome two new commissioners, Jean-Jacques Dumont and Philippe Jamet, appointed by the President of the Republic and the President of the Senate respectively. For the next six years, they will replace Marc Sanson and Jean-Rémi Gouze, whose mandates came to an end on 12th November 2010. ■

Radioactive waste management: progress and outlook

WASTE MANAGEMENT OUTSIDE BASIC NUCLEAR INSTALLATIONS

WASTE MANAGEMENT STRATEGIES FOR WASTE PRODUCERS

LONG-TERM MANAGEMENT OF RADIOACTIVE WASTE

INTERNATIONAL APPROACHES

VIEWPOINT HELD BY ASSOCIATIONS AND CONSULTATION BODIES REGARDING WASTE MANAGEMENT

Radioactive waste management: progress and outlook

by Lydie Evrard, director of Waste and Research and Cycle Installations,
Nuclear Safety Authority (ASN)

The management of radioactive waste has the distinction of combining highly complex processes with an important social element. For the majority of citizens, the question of radioactive waste management continues to be a major source of concern in the nuclear sector, as the results of a Eurobarometer[1] survey on radioactive waste illustrate : Europeans want to see nuclear waste disposal facilities put in place and the development of a more harmonized European approach. Most consider waste disposal to be one of the most significant risks associated with nuclear energy, with only 39% of those who took part in the survey agreeing that it can be done safely.

The conditions for acceptance of a centre waste repository – a project of national interest though it would be installed on an area of limited size - are a decisive factor, something which was particularly evident in France during the recent search for a site for the disposal of long-lived low-level waste; this was also the case abroad, as illustrated by the report of the Swedish experience by S. Laârouchi Engstrom in this issue of *Contrôle*. Radioactive waste management conditions therefore need to be defined on the basis of major scientific research programmes and decision-makers need to attach the greatest possible importance to the essential process of consulting and informing the public concerned and, more generally, the need for transparency vis-à-vis civil society.

What role does the Nuclear Safety Authority (ASN) play in defining and implementing radioactive waste management policy? The ASN's objective is to ensure that all types of radioactive waste have a dedicated management channel and to ensure that the safety of radioactive waste facilities (temporary storage facilities, waste conditioning facilities and repositories) is subject to control. Its actions are designed to ensure that radioactive waste complies with all requirements that allow for the maximum possible safety levels to be achieved, while taking into account radiation protection for people and the environment. Several articles in this feature describe control measures implemented by the ASN, in particular when facilities are commissioned, when they are operational and during the retrieval and reconditioning of legacy waste.

In addition to taking action in France, the ASN attaches a great deal of importance to the drafting of a harmonized regulatory framework, especially at European level. It fully supports the proposal for a directive on the management of radioactive waste and spent fuel, officially adopted by the European Commission on 3 November 2010 and considers that, in defining a legally binding framework in the European Union, this proposal for a directive represents real progress. The ASN was therefore deeply involved in the preparatory work leading up to this proposal for a directive.

Several different types of waste, but only one objective

Radioactive waste, defined by law as radioactive materials for which no further use is foreseen, covers a very broad range of waste (waste from the decommissioning of power plants to hospital waste) and the properties specific to each category are such that they require appropriate management methods.

By convention, radioactive waste is classified according to categories which are defined in order to take account, firstly, of

1. Source: Eurobarometer 2008 on radioactive waste.

the activity of the waste and, secondly, of the period of decay of the radionuclides. Apart from very short-lived waste managed by decay, waste is divided into very low level waste (VLLW), low and intermediate level short-lived waste (LL-SLW, IL-SLW), low level long-lived waste (LL-LLW) and high level and intermediate level long-lived waste (HL-LLW, IL-LLW). However, there are two important aspects to the classification of radioactive waste: there is no single classification system for determining the classification of a type of waste and the radioactivity of the various radionuclides present in the waste needs to be examined in order to classify it.

Furthermore, a type of waste may be assigned to one particular category, but other properties such as its chemical composition might still prevent it from being accepted in the corresponding management channel. Consequently, the category of waste does not necessarily determine its management channel.

VLLW and LL-SLW and IL-SLW currently have dedicated management channels leading to the two surface repositories in Aube. LL-LLW, HL-LLW and IL-LLW still have no disposal channel and are therefore stored temporarily on nuclear sites, pending disposal.

The pillars of the French system

The French system is based on three basic, complementary tools: a dedicated body of legislation and regulations, a National Radioactive Materials and Waste Management Plan (PNGMDR, 'the National Plan'), which is periodically updated by a pluralistic working group that meets several times a year and includes waste producers, political and administrative representatives and associations, the National Radioactive Waste Management Agency (ANDRA) and a dedicated agency for radioactive waste management, with special powers vested in it by law.

Dedicated body of French legislation

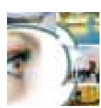
Waste is managed within the framework of a dedicated body of legislation and regulations based on two basic laws and their implementing provisions.

• The law of 13 June 2006 on transparency and safety in the nuclear sector, which established the Nuclear Safety Authority as an independent administrative authority and granted it powers to control the safety of basic nuclear installations and which governs radioactive waste management facilities. This law also contains provisions governing information for the public on nuclear safety.

• The law of 28 June 2006 on a programme for the sustainable management of radioactive materials and waste, which defines national policy for the sustainable management of radioactive materials and waste. This law sets out the sustainable management of radioactive materials and waste and funding for it. Its main provisions are presented in this feature by the Directorate General for Energy and Climate. This law is the product of important work carried out in

Table 1 : Existing or future disposal networks for radioactive solid waste

Activity - Period	Very short-lived < 100 years	Short-lived ≤ 31 years	Long lived > 31 years
Very low level		Dedicated surface disposal Recycling networks	
Low level			Dedicated subsurface disposal being studied
Intermediate level	Management by radioactive decay	Surface disposal (Aube disposal centre) apart from certain tritiated waste and certain sealed sources	Management channels being studied within the framework of Article 3 of the programme law of 28 June 2006 on the sustainable management of radioactive materials and waste
High level		Management channels being studied within the framework of Article 3 of the programme law of 28 June 2006 on the sustainable management of radioactive materials and waste	



collaboration with members of parliament (especially the Parliamentary Office for the Evaluation of Scientific and Technical Options).

The law of 28 June 2006 introduces into the legislative framework new provisions, which concern in particular the drafting of the National Radioactive Materials and Waste Management Plan, which allow for a more precise definition of the remit of ANDRA and for the assessment by operators of basic nuclear installations of the cost of managing spent fuel and radioactive waste and provisions and assets to cover such costs.

The National Plan is a strategic tool for managing radioactive materials and waste and is designed to review existing methods for managing radioactive materials and waste, identify anticipated requirements for storage or disposal facilities and stipulate the capacities and storage periods needed for these facilities. The National Plan also sets out the objectives for radioactive waste for which a definitive management method has yet to be defined. The National Plan also organizes the implementation of research and studies into radioactive materials and waste management, by setting dates for the implementation of new management channels, the creation of new facilities or the modification of existing facilities.

The latest version of the National Plan, which covers the period from 2010 to 2012, calls for management channels to be used to their full potential and for optimization of the allocation of waste to management channels. It has also proposed more targeted action, for example, to improve radioactive materials and waste management in the future and to continue the programme with a view to commissioning two repositories for HL-LLW/IL-LLW and LL-LLW. The National Plan also focuses on operations to retrieve legacy waste in temporary storage, so that it can ultimately be managed using the long-term management channels, and to encourage recycling, in the nuclear line, of waste from the decommissioning of basic nuclear installations. One specific point covers the management of recoverable radioactive materials, such as depleted uranium, so that they can be examined in precautionary studies with a view to deciding if they should ultimately be classified as waste.

The National Plan is therefore a structural and strategic tool for radioactive waste management, because its objective is to identify solutions which guarantee transparent, strict and safe long-term management of all radioactive waste, whatever its origin, especially legacy waste. Its principles are now enshrined in law and its approach is designed to facilitate as much dialogue as possible between the public and stakeholders. This National Plan is fundamental to transparency, because it is based on the national inventory carried out and published by ANDRA, and it describes the management channel for each type of radioactive material and waste. The National Plan is forwarded to Parliament and is evaluated by the Parliamentary Office for the Evaluation of Scientific and Technical Options. Its main recommendations are included in regulatory texts and are therefore binding.

The principle of the National Plan is therefore established in France and its importance, which is unquestioned at national level, has also been fully recognized at European level, where it has been included in the provisions of the proposal for a directive. This concept, which is already considered one of the core elements of the arrangements adopted in France for radioactive waste management, is something of a novelty for other countries, especially in terms of its transparency towards the public.

An agency dedicated to radioactive waste management

The French Environmental Code stipulates[2] that ANDRA (a public industrial and commercial institution) is responsible for the long-term management of radioactive waste, in particular for inventorying radioactive materials and waste on national territory, for carrying out research and studies into storage and deep geological disposal and for defining the specifications for radioactive waste disposal[2]. ANDRA is also responsible for designing, constructing and managing radioactive waste storage centres and repositories. The article by M.-C. Dupuis, Director General of ANDRA, describes the background to and the strategy for this.

The ASN believes that having a dedicated agency for radioactive waste management is fundamental to the implementation of the radioactive waste management strategy and it was actively involved, alongside the IAEA, the Ministry for Ecology, Energy, Sustainable Development and the Sea (MEEDDM) and ANDRA, in organizing the technical meeting held in France in June 2010 on the subject of the establishment of national agencies in charge of radioactive waste management. This meeting followed up the recommendations tabled by the President of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management organized by the International Atomic Energy Agency (IAEA) in May 2009. The President called for studies into specific items of common interest, including the adoption and application of a detailed national plan for spent fuel and radioactive waste management and the creation of national bodies in charge of spent fuel and radioactive waste management.

These pillars of the French legislative framework have attracted a great deal of interest outside France.

Although the three basic elements described above form the cornerstone of the French system for the management of radioactive waste, another dimension also needs to be taken into account, namely how to bring together, at the right level, all the stakeholders required to play a part in the decision-making process for radioactive waste management and how to involve civil society, in a representative manner, in the various bodies working on this issue.

Ensuring everyone has their rightful place in a multidisciplinary approach

Radioactive waste management involves numerous operators and interested parties (waste producers, waste management facility operators, control authorities, associations, and elected representatives) and bringing all the stakeholders together and ensuring that they are represented is an essential factor. Even if the procedure for involving numerous operators may prove to be time-consuming, it is in everyone's interest when it enables a sufficient degree of consensus to be reached.

It is on this basis that work on the National Plan is being carried out, with the involvement of ANDRA, delegates from various bodies (Belgian Control Authority, High Commission for Transparency and Information on Nuclear Safety (HCTISN), associations) and waste producers. In particular, associations are required to play an important role as bodies that represent civil society which, as we have already seen, has specific expectations on this subject. However, as the various participants each have their own objectives, consensus may be limited on

2. Article L 542.12

sensitive issues. The various accounts provided in this review by associations and producers, for example, illustrate how the subject of waste management can lead to very different or divergent points of view. The authorities will be required to play their part in defining the positions that best defend interests in terms of safety and, in particular, radiation protection, which can then be translated into regulations.

Other bodies also play a special role, such as local information committees, which pool their information and expertise within the National Association of Local Information Commissions and Committees (ANCCLI), as described by Benoît Jaquet and Monique Sené in their articles. Their active participation in various national working parties, especially in the field of nuclear materials and waste, or in workshops organized at European level, is such that they are a driving force behind progress in works.

What is the outlook?

New stages for disposal projects

The next few years will usher in a number of new steps for projects to implement new disposal centres.

The process for finding a site for LL-LLW initiated in 2008 was unsuccessful. The search for potential sites must therefore continue, in liaison with the territories and communes. Technical solutions will need to be re-examined in depth and work on inventorying waste will need to continue.

ANDRA will submit a report to the government by the end of 2012. A public debate will be organized before selecting the final site, following an in-depth investigation. The pre-selected communes will be invited to deliberate again, before the site is selected, in order to confirm or refuse their candidature.

The next few years will also be important milestones in deep geological disposal projects for HL-LLW and IL-LLW. The law of 28 June 2006 lays down a timetable prior to commissioning in 2025, subject to authorization. Studies and research will continue with a view to selecting a site and designing the repository. A restricted (30 km^2) area of interest for in-depth reconnaissance (ZIRA), with a view to installing underground facilities for the future repository and potential zones for installing surface facilities (ZIIS), was proposed to the ministers responsible for energy, research and environmental affairs at the end of 2009. On 5 January 2010, the ASN expressed a positive opinion with regard to the government's choice of ZIRA. The design studies are ongoing for the purpose of preparing the application for authorization to create the depository. Given the implications of radioactive waste management, the ASN is closely monitoring progress on this project. A public debate will be organized, in 2012, before the application for authorization is filed. A law specific to the reversibility of disposal will also need to be promulgated before permission is granted to create the repository. This specific aspect (reversibility) of disposal is in response to public demand, but will also need to be taken into account in an integrated vision of the project as a whole, given the safety requirements which need to be taken into consideration when designing the repository.

Thus, the action being taken is designed to sep up management channels in place over the next few years for all waste that can currently be inventoried: legacy waste, waste from current activities and waste that will be produced by facilities currently being implemented. Research is being carried out into new types of reactors and the inventory of waste that will need to be managed in several decades cannot therefore be determined today. The process put in place to date will therefore need to be pursued along the same lines (periodic inventory of waste to be managed, identification of available capacity and additional capacity needed, and public enquiries on the options available). However, it is important that, for projects currently on the drawing board, the inventory of waste to be stored is clearly defined, because the public will want to give an opinion on these data during consultations, through various representative bodies, during public debate and the public that are enquiries organized.

A step towards the adoption of a European directive on radioactive waste and spent fuel management and harmonization of the safety rules at international level

Although radioactive waste management is, first and foremost, the responsibility of the State on whose territory radioactive waste-producing activities take place, various actions are being taken at international level in a bid to define a common framework. As D. Flory and G. Bruno explain in their article, the International Atomic Energy Agency is keen to prepare safety guidelines for facilities before final disposal and for repositories. Furthermore, several initiatives have been taken by the European safety authorities, as illustrated by the work of the Western Nuclear Regulators' Association (WENRA), introduced by S. Theis.

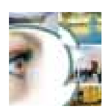
A new milestone has been reached with the adoption of the proposal for a directive by the European Commission, which lays down a binding Community framework, while leaving the Member States the degree of freedom needed in order for the procedure to draft such a text to be completed.

The proposal for a directive on radioactive waste management, officially adopted by the European Commission on 3 November 2010, defines a legally binding framework in the European Union based on internationally recognized safety standards and, as such, represents a real leap forward. This proposal for a directive, the advantages of which are described by U. Blohm Hieber of the European Commission, will round off EU law, following the adoption in 2009 of the Nuclear Safety Directive.

It also establishes a dedicated regulatory framework for radioactive waste and spent fuel management, making provisions, in particular, for the establishment of a competent authority in charge of controlling the safety of waste and spent fuel management, with the financial and human resources needed to complete its mission, the obligation for license holders to allocate the necessary financial and human resources for waste and spent fuel management and the submission of a national radioactive waste and spent fuel management plan and its periodic revision. It introduces the principle of periodic self-assessment of the regulations adopted and of the national programmes, together with peer review. Finally, it aims to ensure transparency towards the public and to involve the public in the decision-making process on radioactive waste and spent fuel management.

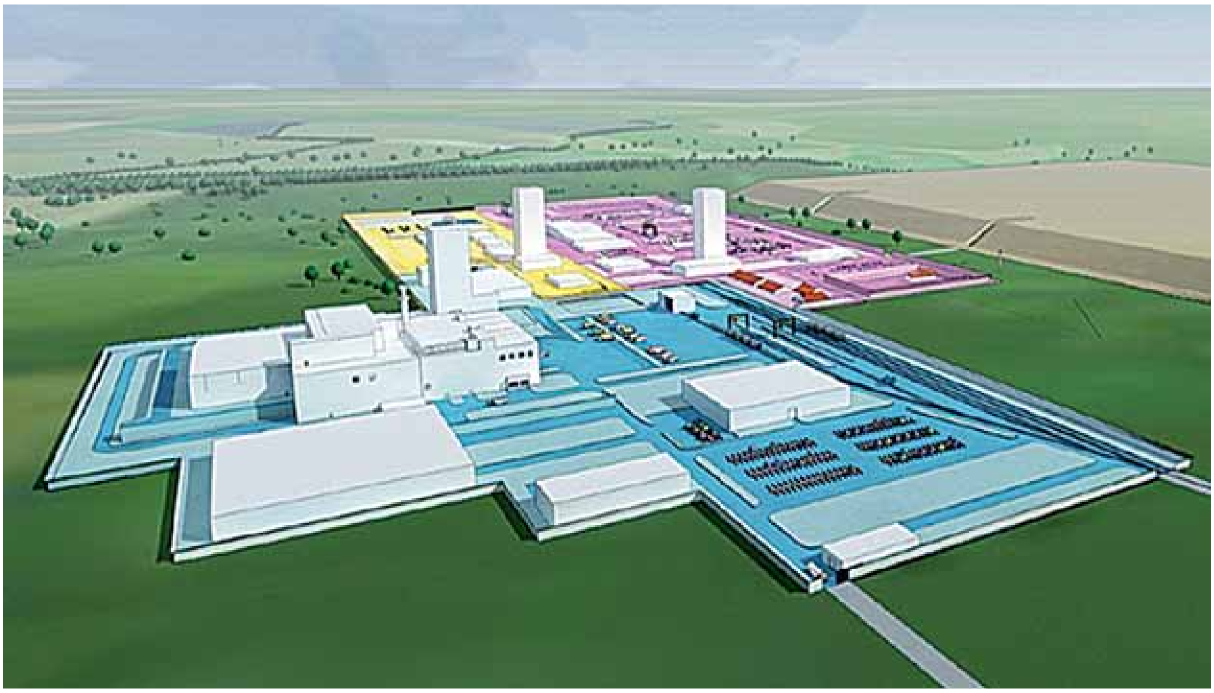
Some will quite rightly see this proposal as a variation on numerous provisions already included in French legislation. Armed with feedback from preparing the PNGMDR and from establishing a control authority and dedicated legislative framework, France did in fact put its full weight behind the draft, especially during the preparatory work carried out under the aegis of ENSREG (European Nuclear Safety Regulators' Group)[3]

3. ENSREG was created in March 2007 as a forum for EU safety authorities and the European Commission. Based on guidelines defined by the Council of Ministers, it deals with safety, waste and spent fuel management and transparency in the nuclear sector at European level. This work paved the way for the Nuclear Safety Directive adopted on 25 June 2009.



in the specific case of the PNGMDR, the very first requests for such a plan were put forward in 2000 by the Parliamentary Office for the Evaluation of Scientific and Technical Options (OPECST) and work started to define how it should be prepared in June 2003. The first official version appeared at the end of 2006 and feedback is currently being provided in order to learn all possible lessons from the exercise recently completed for the period 2010-2012. This specific example illustrates that the adoption of a radioactive waste management plan is a long-term exercise, in which each new step provides additional lessons for further improvements in a context of constant development.

Thus, new arrangements are to be transposed into French law, especially the principle of periodic self-assessment and peer review. The Member States are in fact being asked to organize peer reviews in order to evaluate the regulatory arrangements adopted in the national plan, with a view to achieving best practices in radioactive waste and spent fuel management. The ASN fully endorses such a step and itself underwent such an evaluation in November 2006 by IAEA audit team. New arrangements will therefore need to be integrated into French law in order to make such evaluation mandatory. ■



Schematic diagram of the surface installations for the storage of high-level and intermediate-level long-lived waste

Key players and legislative framework relative to radioactive materials and waste management

by Claude Birraux, MP for Haute-Savoie, President of the Parliamentary Office for the Evaluation of Scientific and Technical Options (OPECST)

While the French industry as a whole appears to have buckled slightly under the pressure of mounting competition in an increasingly diversified international economic area with fewer and fewer barriers, the nuclear industry has maintained a firm grip on the global pole position secured during the 1970s and 1980s as a result of sustained research at national level and by constantly improving the efficacy and safety of the solutions implemented. This was thanks in part to the pro-active companies involved, which have succeeded in developing their international standing while retaining strong national roots, and in part to the unwavering commitment of the authorities, which have issued the necessary guidelines, while at the same time according more and more importance to transparency, in order to improve the channels for the necessary dialogue with the public.

France was also one of the first countries with nuclear energy to establish an organization, a framework and a coherent strategy for managing all its radioactive waste.

Key players in radioactive materials and waste management

Independent bodies play a key role in this field, alongside the authorities.

Within the Government, five ministries are responsible for these issues: research, health, defence, ecology and sustainable development and industry, the last of which prepares and implements government decisions, contributes to the work of European and international organizations (mainly the International Atomic Energy Agency (AIEA) and the Nuclear Energy Agency (NEA)) and oversees public bodies in the sector.

Three industrial bodies, the Atomic Energy and Alternative Energies Commissariat (CEA), which was created immediately after the war and is a key player in research into procedures to separate and transmute nuclear waste, Areva, a company involved in the entire civil nuclear cycle at the cutting edge of waste processing/recycling, and EDF, the leading nuclear electricity producer, account for nearly three-quarters of the radioactive waste produced in France. The last quarter is generated by non-nuclear industries, research institutes, the medical sector and defence.

The national radioactive waste management agency (ANDRA), which was created within the CEA in 1979 and converted to an independent public establishment under the law of 30 December 1991, is responsible for the long-term management of radioactive waste in France. Its main job is to inventory radioactive materials and waste, conduct research on storage and repository sites, design and manage storage and repository sites, collect domestic radioactive items, clean out radioactive sites and provide information to the public on radioactive waste management.

For its part, the Nuclear Safety Authority (ASN), an independent administrative authority created in 2006, prepares regulations on radioactive waste management, controls the safety of basic nuclear installations which generate waste and inspects the various waste generators and ANDRA. It controls the structure of ANDRA in terms of waste acceptance and the radioactive waste management practices applied by producers of waste.

The ASN relies, where necessary, on the expertise of the Radiation Protection and Nuclear Safety Institute (IRSN). This public body, which was set up in 2001 under the joint aegis of the above ministries, is the public expert in the field of nuclear and radiation risks. Its research activities allow it to maintain the level of expertise needed for its mission.

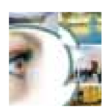
Finally, Parliament has made a decisive contribution towards public policy in terms of nuclear materials and waste management via its Parliamentary Office for the Evaluation of Scientific and Technical Options (OPECST) and constantly monitors its application. This office, which was set up in 1983, is a permanent delegation of eighteen MPs and eighteen senators from the National Assembly and the Senate. Its mission is to inform Parliament and evaluate the laws and public policies that come within its remit. It is assisted by a scientific council of twenty-four experts of international repute.

The work of the OPECST produced two basic laws on material and waste management: the law of 30 December 1991 on research into radioactive waste management and the law of 28 June 2006 on the sustainable management of radioactive materials and waste and the so-called 'TSN' law on transparency and safety in the nuclear sector of 13 June 2006, one of whose rapporteurs (Henri Revol) was also chairman of OPECST, and the other (Bruno Sido) was one of its members.

Law of 30 December 1991

The Parliamentary Office first addressed the question of radioactive waste when the first report was tabled by Christian Bataille in December 1990. This report put forward a set of recommendations which opened up a new approach to this issue, which at the time had reached a stalemate. These recommendations formed the backbone of the law of 30 December 1991.

The main provisions of this law relate, beside the creation of ANDRA, to the organization of research into HL-LLW, the procedure for evaluating this research, the involvement of local populations and elected representatives and the conditions for organizing a new parliamentary debate fifteen years later, in 2006.



The law of 30 December 1991 identified three fields of research for HL-LLW:
– separation/transmutation, the aim of which is to isolate the radioactive elements with the longest life, in order to transform them into shorter lived elements;
– deep geological disposal, which consists of interposing several barriers between the waste and the environment which can confine the radioactivity for a very long period of time;
– conditioning and long-term surface storage, designed so that conditioned waste can be held safely and retrieved in good condition.

A specific body, the National Assessment Board (CNE), was set up to monitor this research and to produce an annual evaluation report and a final report fifteen years later. The board's work is evaluated by the Parliamentary Office for the Evaluation of Scientific and Technical Options, in the form of hearings, once each of the annual reports has been tabled. The CNE is a scientific evaluation body, half of whose members are appointed by OPECST and half by Parliament, and it therefore comes under the Parliament's close scrutiny.

The legislature has also ensured that local populations and elected representatives are involved in decisions to open underground laboratories to study deep geological disposal, both through prior public enquiry and through a local information and follow-up committee (CLIS), which is consulted on all questions with environmental implications. Economic monitoring is also planned, via a public interest group (PIG).

Law of 28 June 2006

The Parliamentary Office then focused on developments in research carried out in application of this first law, as illustrated in the seven reports published on these issues between 1992 and 2005.

At the end of the fifteen-year research period laid down by the 1991 law, several reports were submitted to the authorities (the most important being the CNE report) on the progress made in research; a report entitled 'Taking the long view: a law in 2006 on sustainable management of radioactive waste' was published by Christian Bataille and myself on behalf of OPECST in March 2005. A national public debate on radioactive waste, in which we were involved, was organized between September 2005 and January 2006, before the 2006 programme law was drafted.

The report prepared in March 2005 is a perfect example of the OPECST approach, in that it was based on very wide-reaching consultation (hearings involving nearly two hundred and fifty speakers, including seventy from research centres and installations in France - Champagne-Ardenne and Lorraine - and eighty from abroad during six missions to Germany, Belgium, Finland, Sweden, Switzerland and the United States). In addition, three days of public hearings open to the press allowed national and foreign research institutes, public authorities, decision-makers in Europe and America, local authorities, trade unions and environmental organizations to debate the results obtained for each research sector defined in the 1991 law.

The majority of recommendations formulated in this report were included in the bill tabled by the Government, the preparation of which involved weekly preparatory meetings for three months in the spring of 2006, in which I was involved.

Radioactive waste management is the first issue of national importance to have benefitted from public debate, ten years following the introduction of the procedure. The aim of this debate, which was organized by the National Public Debate

Storage shed for drums awaiting consignment to ANDRA (in yellow) or CENTRACO (in brown) after classification on the automated Camdices line. Solid radioactive waste management area in Saclay

Commission (CNDP), was both to inform the public and identify their concerns and suggestions, in order to clarify the legislative changes. It also confirmed the adequacy, from the public's point of view, of several of the approaches taken in the March 2005 report, namely: the inclusion, in the new law, of all types of radioactive materials and waste, the adoption of a gradual, unhurried approach, with periodic milestones, the inclusion of solidarity between generations, by guaranteeing funding for future expenditure, and between territories, by introducing real economic monitoring, and the importance of reversibility, to ensure that waste recycling can benefit from future scientific progress.

OPECST continued to play a key role when the bill was debated by Parliament, Henri Revol and I acted as its rapporteurs for the Senate's Economic Affairs Commission and the National Assembly.

Main provisions of the 2006 law

The programme law of 28 June 2006 contains numerous new provisions for all types of radioactive materials and waste management, especially in terms of research sectors, the social acceptability of the strategy adopted and financing of radioactive materials and waste management.

With regard to research, the 2006 law took note of the progress made and renewed the three sectors defined in 1991, setting new targets and deadlines for each of these complementary sectors.

On the subject of separation/transmutation, the law recommended that research into separation should continue and, for transmutation, that the industrial potential of the various management channels studied should be evaluated in 2012 and that a prototype 4th generation reactor should be commissioned in 2020. In the disposal sector, the law imposes the principle of reversibility of deep geological disposal, makes provision for an application for authorization to set up the repository to be examined in 2015 and for the repository to be commissioned in 2025. As regards storages, the 2006 law stipulates that modifications and extensions to existing installations or the construction of new installations should be possible by 2015.

The 2006 law also extends to research into other types of waste (graphite, radium-bearing and tritiated waste, sealed sources and mining residues), for which precise deadlines are also stipulated.

It also makes provision for several procedures informing the public and supporting social acceptance of the radioactive materials and waste management strategy.

Thus, the law translates an OPECST recommendation formulated in 2000 in the report by Mrs. Michèle Rivasi on a three-yearly National Radioactive Materials and Waste Management Plan (PNGMDR), designed to take stock of long-term radioactive materials and waste management channels[1]. This plan, which is prepared by a working party, in dialogue with the authorities, industry and associations, allows for complex problems to be addressed, such as the management of legacy waste, and provides a reference document for public information purposes. The second version of the PNGMDR, covering 2010-2012, which was sent to Parliament in March 2010, is currently undergoing evaluation by OPECST, in accordance with the provisions of the law, just as the first version (covering 2007-2009) had previously[2].

Similarly, the authorization procedure introduced in the 2006 law for a future deep geological repository makes provision for public debate, to inform the public and collate their views, and parliamentary debate prior to the introduction of any new bills.

In order to improve transparency in the nuclear sector, the law also extends the mission of the High Commission for Transparency and Information on Nuclear Safety (HCTISN) to organizing periodic consultation and debate on the sustainable management of radioactive materials and waste. The HCTISN, a multidisciplinary body which organizes information, consultation and debate on the risks inherent in nuclear activities and the impact of such activities on human health, on the environment and on nuclear safety, was set up under the law of 13 June 2006.

Finally, the 2006 law defines the financial obligations incumbent on operators of nuclear installations on the basis of the 'polluter pays' principle, relating in particular to long-term costs, such as the cost of decommissioning nuclear installations or managing radioactive waste. Compliance with these obligations is monitored by the authorities, via an administrative authority set up jointly by the Ministry for Economic Affairs and the Ministry for Energy. A National Funding Evaluation Commission (CNEF), which evaluates the cost of decommissioning basic nuclear installations managing spent fuel and radioactive waste, comprising both parliamentarians and qualified persons appointed by Parliament, is responsible for monitoring the work of the administrative authority.

Conclusion

Just as it did after the 1991 law was promulgated, OPECST continued its work on the management of radioactive materials and waste after 2006. The first report on the subject, due at the beginning of 2011, will evaluate the PNGMDR 2010-2012.

Its status as a permanent delegation shared by both chambers and its multidisciplinary approach allow OPECST to take a long view of the issues, by obtaining broad political support, if not consensus on its analyses. These attributes, which are unique in the French institutional environment, have put it in a position whereby it can guarantee real continuity in adapting legislation and in monitoring its application in the long term, which is vital in the nuclear sector, regardless of the uncertainties caused by changing governments.

Thanks to the commitment of OPECST, Parliament has helped, together with other players in the sector, to put France ahead of the game in its approach to radioactive materials and waste management. As a result, France still exercises a certain influence in this sector at international and European level, as illustrated, just recently, by the reforms introduced in the Russian Federation, the debates under way in the United States (for example the study published in September 2010 by the Massachusetts Institute of Technology on the future of the fuel cycle) and the draft European directive on spent fuel and radioactive waste management. ■

1. Report on the consequences of nuclear waste disposal facilities on public health and the environment no 2257 filed by Mrs. Michèle Rivasi MP on 17 March 2000.
2. Report on the evaluation of the National Radioactive Matter and Waste Management Plan no 3793 filed by Mr. Christian Bataille MP and Mr. Claude Birraux MP on 6 March 2007.

Radioactive waste management – a European issue

by Ute Blohm-Hieber, head of the Nuclear Energy, Transport, Decommissioning and Waste Management Unit, DG Energy, European Commission

Radioactive waste management – the precondition to responsible use of nuclear energy

The nuclear landscape in the European Union (EU) is today in a state of rapid change. Numerous Member States have reconsidered the nuclear energy option and its contribution to a balanced energy mix. This approach is fully in keeping with the EU 2020 strategy for smart, sustainable and inclusive growth which aims to build a 'resource efficient' Europe. The pursuit of this objective means that a gradual but determined reorientation is needed towards a low carbon mission economy. In fact, today, nuclear energy already provides 2/3 of low-carbon electricity generated.

There can be no doubt that it is our duty to everyone to guarantee responsible use of nuclear energy. Nuclear safety is – and will continue to be – an absolute priority for the EU. It is based on compliance with the very strictest safety standards in terms of the design, operation and safety of nuclear installations. However, this safety priority also extends to the risk-free management of spent fuel and radioactive waste produced in all the Member States, irrespective of whether or not they have nuclear power plants. Nuclear techniques are also used in the medical sector to treat cancer and in industry, in various applications such as welding quality control.

Reasons to be fearful

Radioactive waste is a source of concern to European citizens. The following figures, based on recent Eurobarometer surveys, clearly illustrate that this is a thorny issue for EU citizens[1]:
– 49% of Europeans consider that radioactive waste cannot be disposed of in complete safety;
– 93% of Europeans consider that a solution urgently needs to be found to this problem right now, rather than shifting the responsibility to future generations;
– 33% would like more information on radioactive waste management procedures and environmental surveillance procedures (which are the main aspect of nuclear energy about which the public would like to know more);
– 82% consider that it would be useful to have European legislation on nuclear waste management regulating this issue within the European Union.

These percentages can be interpreted as the expression of a need for transparency and better coordination of regulations within the European Union.

Public dissatisfaction is the result not only of the frequent lack of open and transparent debate on radioactive waste but also because most Member States have yet to start putting solutions in place to guarantee the definitive and safe disposal of all their radioactive waste.

This is especially true in the case of spent fuel, which qualifies as waste, and high level waste. Although the scientific community agrees, as a whole, that the most suitable solution for managing this type of waste is deep geological disposal, most of this waste in the EU is still stored on site in tanks or storage facilities constructed for the purpose, often close to nuclear power plants. In most cases, there is no long-term solution for managing this type of waste and, often, there are not even any plans to find a solution.

Management and elimination of short-lived low level and intermediate level waste

has now reached a level of industrial maturity, as we can see in France. Most Member States with nuclear power plants are expected to commission waste disposal installations for this type of waste by 2020.

Unfortunately, the situation as regards high level waste and spent fuel considered as waste is more delicate. This is not due to a lack of solutions. The solutions exist. At the end of 30 years of research, there is broad scientific and technical consensus that deep geological disposal is the safest and most sustainable solution, even if further research and development into exactly how this solution is to be implemented is still needed for some sites. However, today only a very small number of countries, such as France, Finland, Sweden and again Germany, are actually treading this path. Moreover, there is a wait-and-see attitude which, in some countries, goes as far as hoping that it will be possible to export waste to third countries outside the EU.

International regulations, such as the Joint Convention, clearly define the principles; spent fuel and radioactive waste need to be managed without imposing undue burdens on future generations. In this sense, the approach adopted by France in disposing of radioactive waste in passive safety repositories with the technical facility to recuperate disposed radioactive waste is an excellent example of the application of the fundamental principles of radioactive waste management.

Waste management therefore requires political commitment for the duration and the adoption of vast national programmes in which there is no place for wait-and-see policies. A determined approach is the only way to guarantee coherent progress in the implementation of all stages of the radioactive waste management cycle, from production through to disposal.

Transparency is prerequisite to success in the radioactive waste management sector, as in the nuclear sector as a whole. That is why introducing geological repositories presupposes respect

1. Data extrapolated from special Eurobarometer survey 324 (2010) 'Europeans and nuclear safety', p. 52, 106, 110 and special Eurobarometer survey 297 (2008) 'Attitudes towards radioactive waste'.

for modern concepts of governance based on a step-by-step approach, with local stakeholders involved at an early stage.

What is the European Union doing?

The emphasis placed by the EU on radioactive waste has increased considerably since the Euratom Treaty was signed in 1957. At that time, the question of radioactive waste was not a priority; in fact, whereas numerous articles in the Treaty deal with investments, research and supplies, only one (Art. 37) deals with radioactive waste, calling on the Member States to notify the Commission of their plans for the disposal of radioactive waste. This is illustrative of the nuclear legislation in the 1950s, which was interested primarily in the first part of the nuclear fuel cycle, in order to guarantee the security of energy supply to support industrial growth in Europe at that time.

The situation has changed radically since then in this respect and the focus is now on management of the end of the nuclear fuel cycle.

The Community started in 1980 with the adoption of a "Community plan of action in the field of radioactive waste"[2], the scope of which was then extended in 1992[3], instructing the Commission to make a "continuous analysis of the situation". Since then, the Commission has published six situation reports on the management of spent fuel and radioactive waste in the EU. A seventh report is under way. The questions covered by these reports include national radioactive waste management strategies, a description of the funding mechanisms, stocks of waste and forecasts of volumes of waste in coming years[4].

The range of EU legal instruments applicable to spent fuel and radioactive waste management has grown over recent years, with the majority being based on the authority vested in Euratom to act to protect the public and the environment.

General EU legislation on the protection of the health of workers and the general public is based on basic safety standards, the most recent version of which is contained in Directive 96/29/EC[5]. It also applies to spent fuel and radioactive waste management.

More detailed provisions are contained in the Directive on the control of high-activity sealed radioactive sources and orphan sources which is broadly applied in industry, medicine and research[6].

There is a specialized directive governing shipments of spent fuel and radioactive waste and shipments of spent fuel from, in transit in, or destined for an EU Member State[7]. It sets out a harmonized procedure for the authorization of such transfers by the competent national authorities.

The Grimsel underground laboratory in the Swiss Alps is used year round to research safe disposal methods for high-level waste

The Commission is also considering the question of uranium mines and processing residues and will shortly be publishing a report on the subject. In fact, two directives deal with this question: the EC directive on the managing of mining waste[8] and the basic safety standards dealing with aspects of radioactivity (excluded from the scope of the EC directive).

Responsible and safe management of spent fuel and radioactive waste requires adequate financial resources. That is why a Commission recommendation adopted in 2006 calls on the EU Member States to ensure that funding mechanisms are in place for decommissioning power plants[9]. This recommendation basically covers the amount of such funds considered adequate, their availability when needed and their transparent management. It also stipulates that the "polluter pays" principle must be applied across the board. The Commission publishes periodic reports on the implementation of this recommendation by the Member States[10].

For over 30 years, the Commission has also been funding research into radioactive waste management under its various framework programmes, such as the formulation of best practices for public participation and the development of techniques for minimizing waste (such as separation and transmutation).

2. Council Resolution of 18 February 1980 on the implementation of a Community plan of action in the field of radioactive waste.

3. Council Resolution of 15 June 1992 on the renewal of the Community plan of action in the field of radioactive waste.

4. The most recent situation report is contained in two documents: the Report from the Commission to the European Parliament and the Council – Sixth situation report on radioactive waste and spent fuel management in the European Union (COM/2008/0542 final) and the Commission staff working document accompanying the Commission report to the European Parliament and to the Council – Sixth situation report on radioactive waste and spent fuel management in the European Union (SEC(2008) 2416 final/2).

5. Council Directive 96/29/EC of 13 May 1996 laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation (OJ L 159, 29.06.1996, p.1).

6. Council Directive 2003/122/Euratom of 22 December 2003 on the control of high-activity sealed radioactive sources and orphan sources (OJ L 346, 31.12.2003).

7. Council Directive 2006/17/EC of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel (OJ L 337, 05.12.2006, p. 21).

8. Directive 2006/21/EC on the management of waste from extractive industries (OJ L 102, 11.04.2006, p. 15).

9. Commission Recommendation of 24 October 2006 on the management of financial resources for the decommissioning of nuclear installations, spent fuel and radioactive waste (2006/851/Euratom, OJ L 330, 28.11.2006, p. 31-35).

10. See in particular the second report and accompanying working document entitled "Communication from the Commission to the European Parliament and the Council, Second report on the use of financial resources earmarked for the decommissioning of nuclear installations, spent fuel and radioactive waste", Brussels, 12.12.2007 (COM(2007) 794 final) and the Commission staff working document "EU decommissioning funding data" accompanying the second report, Brussels, 22.12.2009, (SEC(2007) 1654 final/2).

This has resulted in a technical platform for implementing geological disposal (IGD- TP[11]) with broad participation among the Member States. Its members agree that there needs to be at least one geological repository which meets the safety standards for high level waste in Europe by 2025. The IGD-TP also aims to provide a forum for sharing experience and transferring expertise in this field and is expected to help develop trust and facilitate the coordination of resources for the purpose of implementing geological disposal.

Commission proposal for a directive on spent fuel and radioactive waste management

As indicated above, the EU is in the process of defining a legal framework based on the most stringent safety, security and non-proliferation criteria, both for nuclear energy and non-energy applications, in the interest of all its Member States.

An important milestone on this path was reached last year, when the Council adopted the directive on the safety of nuclear installations with the support of the 27 Member States[12]. The European Parliament and the European Economic and Social Committee have also fully endorsed the proposal. The EU is the first regional key nuclear play in the world to offer a stringent and binding legal framework on nuclear safety.

This legislation is in keeping with the very important ruling handed down by the European Court of Justice in 2002[13], which clearly stipulates that it is not appropriate *"to draw an artificial distinction between the protection of the health of the public and the safety of sources of ionizing radiation"* and that it therefore comes within the competences of Euratom to prepare legislation on the safety of nuclear installations.

The Nuclear Safety Directive applies to nuclear installations, i.e. (art. 3) to:

(a) enrichment plants, nuclear fuel fabrication plants, nuclear power plants, reprocessing plants, research reactor facilities and spent fuel disposal facilities and ;

(b) disposal facilities for radioactive waste that are on the same site and are directly related to nuclear installations listed under point (a).

Consequently, not all spent fuel and radioactive waste management facilities come within its scope. Off-site storage facilities and repositories used for the disposal of radioactive waste are not included, nor are waste management activities.

The Swedish underground laboratory, Äspö IRSN visit to the installations run by the SKB, which is in charge of managing Swedish waste

This is why, on 3 November 2010, the Commission presented a new proposal for a directive on spent fuel and radioactive waste management, covering all civil activities and installations that process spent fuel and radioactive waste.

Once it has been passed, this legislation will form the second pillar of the European legal framework governing the responsible use of energy.

The proposal translates the obligations in the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management ('the Joint Convention'[14]) and the corresponding obligations and basic principles of the IAEA[15] into binding EU legislation. The Commission proposal goes beyond these, because it includes an obligation for the Member States to prepare national spent fuel and radioactive waste management programmes and to periodically update and revise them. This will enable the Commission both to ensure the safety of radioactive waste management activities and installations and to ensure that the Member States take the political decisions needed for the purpose of long-term disposal of all their radioactive waste and finalize national programmes to implement them without delay.

Various groups of stakeholders provided input during the preparation of this legal instrument. A very important contribution was received from the European Nuclear Safety Regulators Group (ENSREG) set up in 2007 under a decision passed by the European Commission. ENSREG is a group of high-ranking regulators whose role is to "help establish the conditions for continuous improvement and to reach a common understanding in the areas of nuclear safety and radioactive waste management[16]". This advisory group played an important role when the Commission was drafting the current Nuclear Safety Directive and the draft proposal on radioactive waste, by putting forward suggestions that could be used in this legislative text.

A significant contribution was also received from the European Nuclear Energy Forum (ENID). This forum was set up in 2007 and is a meeting place for all stakeholders in the nuclear sector (authorities, European institutions, nuclear industry, electricity consumers and civil society). A special ENID sub-working group dealing with radioactive waste management has issued a summary paper on disposal in geological repositories in the EU and its suggestions were also taken on board by the Commission when drafting its proposal.

Last but not least, an online public enquiry has been launched on the European Commission's website, asking the public to reply to a questionnaire by stating their opinion on the need for an EU instrument on radioactive waste. The in-depth evaluation of the impact of this proposal refers in detail to all these contributions.

11. *www.igdtp.eu/*
12. JO L 172, 2.7.2009, p. 18.
13. Judgment of 10 December 2002 in case C-29/99 Commission v Council [2002] ECR I-11221).
14. Commission Recommendation of 24 October 2006 on the management of financial resources for the decommissioning of nuclear installations, spent fuel and radioactive waste (2006/851/Euratom, OJ L 330, 28.11.2006, p. 31-35).
15. See in particular the second report and accompanying working document entitled "Communication from the Commission to the European Parliament and the Council, Second report on the use of financial resources earmarked for the decommissioning of nuclear installations, spent fuel and radioactive waste", Brussels, 12.12.2007 (COM(2007) 794 final) and the Commission staff working document "EU decommissioning funding data" accompanying the second report, Brussels, 22.12.2009, (SEC(2007) 1654 final/2).
[16] *www.igdtp.eu*

Deep geological disposal of LILW-SL in Finland IRSN visit to the Olkiluoto site

The content of the draft directive

We were especially careful, when drafting this proposal, to ensure that it would be in keeping with the Nuclear Safety Directive. As these two texts have no gaps or overlaps, all radioactive waste management facilities will benefit from the same level of protection. Its scope extends to all stages in the management of spent fuel and radioactive waste, only excluding waste of military origin, waste from extractive industries and authorized waste. It is based on the principle of ultimate responsibility on the part of the Member States for the management of their waste (with primary responsibility resting with the authorization holder), minimization of waste, measures to prevent an excessive burden on future generations, the links between all stages in the management of radioactive waste and the priority of long-term safety.

The draft proposal calls for all radioactive waste to be disposed of in the Member State in which it was generated, with the exception of special agreements between Member States.

The Member States will need to introduce a national framework which takes account of the regulatory and institutional aspects (for example by guaranteeing that there is a competent and independent regulatory authority). The safety approach is based on the need to prepare safety arguments when applying for authorization for installations and activities. The safety arguments and the evaluation justifying them must demonstrate that the planned activity or installation offers the highest level of protection, particularly with regard to disposal. It must list the precautions taken in order to guarantee post-closure safety, using passive means wherever possible. Other provisions include the need to develop adequate technical skills, have available funding, put quality assurance programmes in place and inform and involve the public in decisions on radioactive waste management.

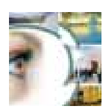
There is one very important provision requiring the Member States to introduce and regularly update national programmes to implement spent fuel and radioactive waste management policy. These programmes must include inventories of and production forecasts for spent fuel and waste, the technical concepts and solutions from production through to disposal, forecasts for the post-closure period, including institutional control, a description of R&D measures, cut-off dates and key dates, the main performance indicators, cost assessments and financing methods.

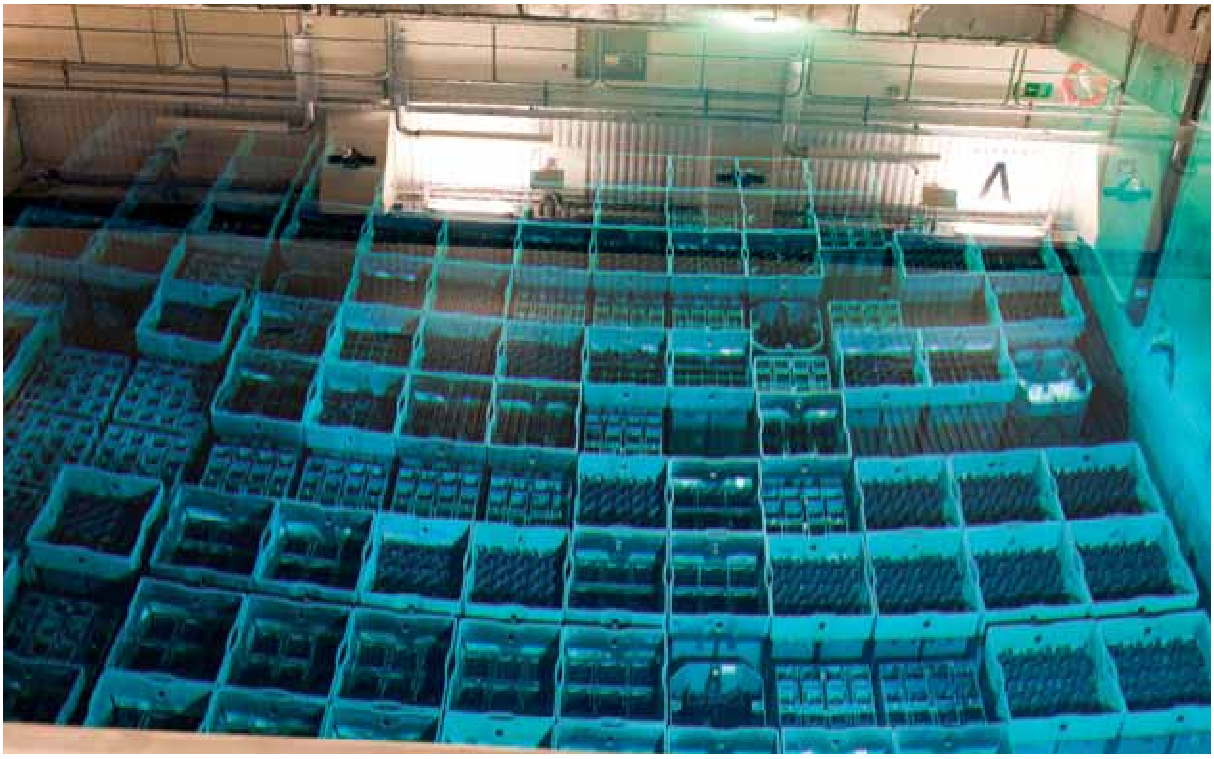
The Commission will be notified of these programmes and may request clarifications or revisions in keeping with the spirit of the directive. Compliance will be controlled on the basis of programme monitoring and the reports submitted to the Commission every three years, in line with the reporting cycles adopted in the Joint Convention. Member States will also be required to self-assess and to undergo peer review of the national framework at least every ten years.

Conclusions and outlook

The proposed directive will give the EU the most comprehensive legal framework on nuclear safety. All activities and installations relating to spent fuel and radioactive waste management will be covered by the EU legislation.

However, there are still major obstacles to overcome at EU level in the radioactive waste sector. Once the directive has been adopted, the Commission will monitor its implementation, in the stated aim of encouraging the Member States to pass





Subsurface (-25 meters) storage pool for spent fuel in granite. IRSN visit to the facilities of the Swedish waste manager, SKB

decisions on the disposal of their radioactive waste, especially high level waste. Based on the Member States' reports, the Commission will present reports to Council and the European Parliament on progress made in implementing the directive.

The Commission will continue to monitor the implementation of its funding recommendations.

A great deal still needs to be done in order to achieve safer and more responsible radioactive waste management in Europe, in some Member States more than in others. In light of the vigorous support and contributions we have received over recent months and years, we are confident that, once it has been adopted by the Council, the final directive will encourage new solutions in the EU and serve as a model and point of reference for other countries and regions, by underlining the important role of the EU in this sector. ■

Governance relative to radioactive waste management – the Act of 28 June 2006

by Pierre-Franck Chevet, director general of Energy and Climate, Ministry for Ecology, Sustainable Development, Transport and Housing

In France, the Act of 30 December 1991 on research into radioactive waste management, known as the Bataille Law (law no. 91-1381), is seen as the legislative act underpinning the long-term policy for high level (the most radiotoxic) nuclear waste. At the time, the main concern was to establish the framework for a three-pronged research programme for long-term management (deep geological disposal, long-term surface storage or advanced transmutation and separation of radioactive waste). The law set a fifteen-year deadline for a final report in order to prepare a new legislative framework for the future. However, it only dealt with high level waste.

Various evaluation and consultation initiatives were launched on the basis of the summary reports filed with the authorities by the bodies responsible for the various research subjects (ANDRA for disposal and the CEA for storage and separation/transmutation), with parliamentary and government support, the broadest of which was the public debate launched at the end of 2005. The public debate was not confined to high level waste (scope of law 1991); it covered all radioactive waste and it was clear from the conclusions that reversible deep geological disposal was needed for high level and intermediate level long-lived waste and that radioactive waste management needed to be extended to radioactive materials.

The results of this process of evaluation and public consultation were used to draft a bill which was included in the process started in 1991, but extended in scope to cover all radioactive materials and waste. Extensive discussion during parliamentary review improved it still further. The final text was adopted at second reading on 15 June 2006 and the programme law on the sustainable management of radioactive materials and waste (law no. 2006-739) was promulgated on 28 June 2006.

The 1991 law was passed with the precise aim of organizing research into high level long-lived radioactive waste. Research work has been carried out over this fifteen-year period, but information, exchange and consultation procedures have also been put in place which have highlighted the need to improve how the management of radioactive substances other than high level nuclear waste is organized. That is why the 2006 law is much broader in scope that the initial 1991 law. It establishes a general framework for the management of all radioactive materials and waste and organizes information in the subject and consultation processes.

The 2006 law starts by reiterating that producers of spent fuel and radioactive waste are primarily responsible, in keeping with the "polluter pays" principle, in order to ensure that the radioactive materials and waste caused by their activities are managed and that management is funded.

Unloading of a concrete container into a LILW cell in the Aube LILW storage facility (CSFMA)

The law also bans the disposal of foreign radioactive waste in France and the disposal of waste produced by processing foreign waste and fuel in France. It makes the importation of spent fuel or radioactive waste into France subject to intergovernmental agreements.

The management of radioactive materials and waste management is organized in a statutory National Radioactive Materials and Waste Management Plan (PNGMDR) which sets out the structural axes of materials and waste management policy:
– reduction in the quantity and harmfulness of waste, especially reduction at source, by processing spent fuel and, in the future, if necessary, by advanced separation/transmutation;
– storage of radioactive materials pending processing and of radioactive waste pending disposal;

Table 1: Act of 28 June 2006 – implementing acts

	Subject of decree or order	Article of law	State of progress
National radioactive materials and waste management policy	Definition of a National of a Radioactive Materials and Waste Management Plan	Art. 6	Decree of 16 April 2008
	Management of foreign waste and processing contracts	Art. 8	Decree of 3 March 2008
	Nomination of members of the CNE	Art. 9	Decree of 5 April 2007
	Type of information required for national inventory and PNGMDR	Art. 22	Decree of 29 August 2008
Support for research in Bure underground laboratory	CLIS	Art. 18	Decree of 7 May 2007
	PIGs – generic decree	Art. 13	Decree of 14 December 2006
	Definition of the proximity zone - Meuse and Haute-Marne PIG	Art. 13	Decree of 5 February 2007
	'Support' tax: fraction paid by OIGs to communes in the 10-km zone	Art. 21	Decree of 7 May 2007
	'Support' and 'technological diffusion' tax rates	Art. 21	Decree of 26 December 2007
	Consultation zone for new disposal centres	Art. 12	To be published in 2012
Financing provisions	Additional 'research' tax rate	Art. 21	Decree of 26 December 2007
	Securing long-term nuclear costs	Art. 20	Decree of 23 February 2007
	Creation of the CNEF	Art. 20	Decree of 20 June 2008

– disposal as a permanent solution, especially reversible deep geological disposal for intermediate and high level long-lived waste, which cannot be disposed of in surface or shallow underground disposal for reasons of nuclear safety and radiation protection.

For each of these axes, the National Radioactive Materials and Waste Management Plan aims to identify the way forward and set milestones in order to monitor and encourage progress. The plan also identifies the basic subjects of research. All these recommendations are regulated by decree. In order to ensure that the plan is a pro-active and efficient tool, the law requires it to be updated every three years; the first version was sent to Parliament in 2007 and the second, three years later, in March 2010.

For high level long-lived waste, the 2006 law contains provisions for continuing research, following on from the 1991 law, but goes beyond organizing research; it also defines precise operational objectives for each of the three axes and stipulates the authorization procedures for future deep geological disposal.

One of the cornerstones of the framework policy on radioactive waste management in France was the creation in 1991 of ANDRA, the National Radioactive Waste Management Agency, which is in charge of the long-term management of radioactive waste. The 2006 law set out its mission in the research sector and assigned missions of general interest to it (national reference inventory every three years, responsibility for radioactive waste and clean-out of radioactive sites whose owners are unknown or have defaulted).

In addition to structuring radioactive materials and waste management so as to avoid shifting the knock-on effects of nuclear power (decommissioning of installations, waste management etc.) on to future generations, the 2006 law makes provision for securitization of the corresponding funding by operators of basic nuclear installations (BNI). It also sets out obligations relating to funding for research programmes and economic growth plans. Generally speaking, funding has been based on the principle that producers are responsible for their waste management.

In fact, operators must evaluate all the decommissioning costs and spent fuel and radioactive waste management costs for their installation. The provisions for these future costs must be covered by dedicated assets, in accordance with the methods set out in the law and the rules contained in the decree of 23 February 2007 and the ordinance of 21 March 2007. In order to prevent and limit the cost to future generations, the regulatory framework put in place requires dedicated assets to be sufficiently secured, diversified and liquid. The authorities monitor compliance with statutory obligations imposed on nuclear operators (the Directorate General for Energy and Climate (DGEC) is the designated supervisory authority). As part of this system, operators filed their second triennial reports in the summer of 2010, setting out all the measures taken to discharge their obligations.

The same philosophy has been applied to funding for research and studies carried out by ANDRA into storage and deep geological repositories, which is the responsibility of the producers of radioactive waste. A fund is provisioned by a "research" tax, in addition to the tax on basic nuclear installations. This fund secures financing for ANDRA and is fully in keeping with the "polluter pays" principle.

In order to provide a strong, integrated set of provisions, the law also sets out funding methods for the construction, operation, closure and monitoring of future storage and disposal facilities constructed by ANDRA for high level and intermediate level long-lived waste. A dedicated fund has been set up within the Agency to provide the financial resources managed by waste producers when the time comes.

In addition, ANDRA's general interest missions are funded from a government grant for carrying out the national inventory and

View of the entrance to the site of the Bure laboratory or the Meuse/Haute-Marne underground research laboratory (LSMHM)

managing radioactive waste or contaminated sites whose owner is unknown or has defaulted.

Finally, the law reiterates the need for transparency and dialogue expressed in the law of 13 June 2006 on transparency and safety in the nuclear sector, by tightening up control of waste management as a whole.

Thus, in the research sector, the National Assessment Board (CNE) established under the 1991 law is responsible for an annual evaluation of the state of progress in research and studies into radioactive materials and waste management.

As regards securing financial resources by operators for the purpose of constructing future disposal facilities, the law makes provision for a National Assessment Board to assess the cost of decommissioning basic nuclear installations and managing spent fuel and radioactive waste (CNEF).

As regards transparency and dialogue with people living close to the underground laboratory in Meuse (Haute-Marne), a local information and monitoring committee chaired by an elected representative has been set up under the aegis of the laboratory.

As regards the creation of a deep geological repository, the law makes provision for public debate and for a future law setting out the conditions of reversibility of radioactive waste disposal before any decree is issued authorizing any such repository.

Moreover, the law of 28 June 2006 forms part of the general drive towards transparency in the nuclear sector initiated by the legislature, stating that the High Commission for Transparency and Information on Nuclear Safety (HCTISN) set up in the law of 13 June 2006 on transparency and safety in the nuclear sector is responsible for organizing periodic consultation and debate on the sustainable management of radioactive materials and waste.

List of implementing texts

The law stipulated that various implementing decrees would be needed for the purposes of its application. All the decrees required within three years of passing the law have been published. Table 1 lists all the implementing texts as of 31 October 2010. ■

Managing radioactive waste produced at secret basic nuclear facilities

by Marie-Paule Elluard, project manager at the Nuclear Defence Safety Authority, Ministry of Defence

Role of DSND

The Nuclear Safety and Radiation Protection Delegate, responsible for defence-related activities and installations (DSND), reports to the Minister of Defence and the Minister for Industry. The DSND is responsible for studying and proposing nuclear safety and radiation protection policy specifically applicable to secret basic nuclear installations classified by decision of the Prime Minister (SBNI) to the ministers responsible and for monitoring its application.

The DSND drafts regulations for managing waste within the boundaries of SBNI, in keeping with the principles set out in the Environmental Code. For example, chapter VI of the ordinance of 26 September 2007 setting out general technical regulations designed to prevent and limit the negative effects and external risks from secret basic nuclear installations reiterates the need for all SBNI operators to take all necessary measures to reduce the volume and radiological, chemical and biological toxicity of the waste produced in their installations and to optimize waste management by recovery, processing and recycling where possible and to use disposal for final waste only.

The DSND monitors the safety of each stage in the waste management process (production, processing, storage, transportation and disposal).

Safety of waste processing and conditioning facilities

Waste processing and conditioning facilities are individual installations, the technical equivalent to a civil basic nuclear installation (BNI). They form part of a secret basic nuclear installation (SBNI) which may be incorporated into the nuclear site. These installations are responsible for the waste from SBNI; often they are old installations which need to be renewed or replaced.

The authorization to operate an installation is based on a safety standard approved by the DSND. The Defence Code and the decree creating the facility stipulate that safety- and radiation protection-related structural and operational arrangements must be subject to periodic technical review (once the installation has been in operation for around ten years). The purpose of this safety review is to establish if appropriate arrangements have been made to maintain safety at an acceptable level in accordance with current safety standards and practices. This review is based on an in-depth analysis of the operator which the DSND commissions from an outside expert, usually from the IRSN, and from committees of experts. The opinion of the IRSN and these committees enable the DSND to set out the conditions under which the installation can continue to operate. This procedure has resulted in decision by DSND to stop operations for a brief period, as described below.

Pierrelatte SBNI solid waste processing plant (SWPP)

The SWPP on the Tricastin site is a separate facility of the Pierrelatte SBNI, which collects, manages, processes, conditions and disposes of solid radioactive waste produced by the AREVA NPP in Pierrelatte and by other upstream industries (COMURHEX, SOCATRI, SET, FBFC etc.). The waste produced is dispatched to ANDRA disposal channels (CSA, CSTFA). The SWPP is in perpetual operation. However, it is an out-dated facility which no longer meets current standards for nuclear installations. This being so, the DSND advised the operator that the installation would not be authorized to operate beyond 2014. The safety options for a future solid waste processing plant were examined by the DSND in 2008. The operator's development strategy for the Tricastin site was reviewed and this project was postponed as a result. In light of the transfer of safety controls of the activities of the SBNI from the DSND to the Nuclear Safety Authority (ASN), replacing an SWPP is now being studied together with the ASN. Both safety authorities insist that replacement is unavoidable and this has major implications for this site.

Marcoule SBNI effluent processing plant (LEPP)

The LEPP was commissioned in 1958. The most recent safety committee examination of this installation was in 2008. It found that there had not been any noteworthy incidents over recent years from the operation of this installation from a safety point of view and that radiation exposure of the staff had been maintained at low levels. However, this plant is an old installation; this is particularly relevant to the unit used to condition sludge in bitumen. This being so, the DSND authorized the LEPP to continue operating using current procedures for a limited period of time. The operator has started a project to renovate the plant (AMETISTE project). The future LEPP will comprise new buildings and current buildings classified as 'permanent'. The use of bitumen as a matrix for sludge will be replaced in 2014 by cement. This is acceptable in principle and the DSND will ensure that the 2014 deadline is met.

Marcoule vitrification unit (VW)

The Marcoule vitrification unit was commissioned in 1978 and, since then, has mainly accepted and vitrified rinsing solutions from operations to clean out factory UP1. The safety review file for this installation was presented to the safety committee in 2009. The feedback from the VW was examined and illustrated that risks of exposure to ionizing radiation and failure, thermal and handling risks were properly under control. The operator also undertook to improve measures to prevent and control fire, explosion and radiolysis risks in order to continue vitrification operations and commission and operate the new evaporation unit for a period of ten years. The DSND therefore authorized the vitrification and evaporation units until 2012.

Waste management

Under Article 44 of the decree of 26 September 2007, SBNI operators must prepare a waste plan setting out their strategy and action to reduce the volume and harmfulness of waste produced in their installations.

Operators must set the following objectives in a waste plan:
– to minimize the production of waste, by trying to produce less radiotoxic waste;
– to give precedence to recycling or recovery networks, rather than disposal networks, where the current costs are the same;
– to recycle and recover waste produced, where technical and financially possible;
– to ensure that there is a disposal route for all types of waste produced and, if not, to find one;
– to evaluate waste which has an operational network and only to store it on site where absolutely necessary;
– to absorb legacy waste in storage;
– to guarantee the traceability of waste management operations.

The executive summary (part V of the waste plan) forms an integral part of the standard for the installation and is subject to approval by the DSND.

All SBNI have a waste plan which has been examined by the DSND.

As part of this process, the DSND closely monitors the management of waste actually produced and the programmes for retrieving legacy waste and ensures that packaged waste is transferred for disposal, depending on the availability of disposal channels.

Radioactive waste from defence SBNI (military air and naval bases) is mostly evacuated to ANDRA repositories.

Some SBNI store legacy radioactive waste, all of which is destined to be evacuated in time to ANDRA repositories. This storage is included in the national inventory established by ANDRA. The situation at these SBNI is described below.

Valduc INBS

The waste produced and stored in the Valduc SBNI is divided into two main categories: alpha-emitting waste and tritiated waste.

The operator has taken steps to evacuate legacy waste with an operational disposal channel and to improve storage conditions for waste awaiting a disposal channel.

A new storage building is to be commissioned in 2011. The conditioned low to high level waste contaminated with alpha-emitting radionuclides produced by SBNI will be stored here until such time as it can be evacuated to defined disposal channels or disposal channels in the process of being defined. This building will eventually replace the oldest buildings. Its design will guarantee that waste is temporarily stored in conditions which represent a major improvement in terms of safety, compared with current storage.

For tritiated waste, a new processing plant has considerably improved the capacity to absorb legacy waste but is inadequate in terms of guaranteeing satisfactory management of this

Storage shed at the vitrification workshop in Marcoule The containers of vitrified waste are placed in cells at the site in Marcoule, for cooling inside ventilated pits

waste. In fact, the lack of any operational disposal channel is causing a constant increase in stocks in storage. The safety conditions of current storage of tritiated waste are considered satisfactory in the short- and medium-term. The long-term solutions examined are in keeping with the approach set out in the study submitted by the CEA at the end of 2008 in line with the PNGMDR decree. Thus, the new storage to be constructed is in keeping with the principles set out in the study.

Marcoule INBS

Processing of spent fuel stopped in 1997. The installation is currently being cleaned out and decommissioned. Packaging and repackaging of legacy waste is continuing. There are several storage facilities, the most important of which are:
– the VW pits for tritiated waste;
– the LEPP caves for effluent processing waste: sludge packaged in bitumen in 230 litre drums;
– the pits and buildings in the north zone;
– the multipurpose storage for drums of sludge packaged in bitumen in 380-litre double drums under the retrieval programme for the pits in the north zone and the LEPP caves;
– the decladding and MAR 400 pits for structural fuel waste and operational waste.

The capacity of the packaging facilities for waste destined for surface disposal would appear to be adequate, in light of the forecasts presented, for the purpose of processing waste generated by decommissioning operations and from operation of the site facilities, including neighboring civil BNI.

A strategy has been put in place for waste which still has no disposal channel. It is based on work to improve the storage facilities for legacy waste which cannot be quickly retrieved (for example, work to seal cave roofs) and work to extend existing facilities or construct new facilities to implement legacy waste retrieval programmes. However, for non-immobilized waste which represents an important source over time, the DSND has asked the operator for new proposals to improve the safety of storage conditions and new proposals for retrieval plans, with priority for non-immobilized waste for disposal to existing disposal channels or transfer to safer storage. The operator duly responded to this request in 2009, mainly by planning the retrieval of certain sludge waste packaged in bitumen and certain technological waste.

The DSND is monitoring the undertakings made, in order to ensure that they are discharged by the operator. However, as these plans are highly sensitive to outside uncertainties beyond

Aerial view of the Pierrelatte nuclear power plant at the Tricastin site

the operator's control (mainly the commissioning dates of future disposal sites), the DSND has asked the operator to carry out a draft study into one or two storage cells, in case there is any change of date for future disposal.

Pierrelatte INBS

The waste generated by production and decommissioning activities is evacuated to existing management channels (CSTFA, CSA and CENTRACO) and is not put into long-term storage on site.

There are two legacy waste storage sites: the 'hill' and the pits in the north zone. The 'hill' contains gaseous diffusion barriers, technological waste, fluorines and inactive, chromium-rich sludge. The diffusion barriers and technological waste present in the 'hill' need to be evacuated to ANDRA repositories by 2013. The future of the fluorines and chromium-rich sludge is currently being considered.

The twelve waste pits in the north zone contain debris from the demolition of slightly contaminated buildings following the clean-out of premises housing research activities. The DSND has asked the operator to piece together the history of the waste pits in the north zone and to provide a rehabilitation plan. The classification, retrieval, conditioning and evacuation of waste to an authorized management channel are currently being studied. Two of these pits will be processed in 2011 as a pilot site.

For the management channels currently being studied, we need to know if the waste in question is to be stored on site or retrieved. The necessary timelines and operations have to be defined. If additional studies are needed in order to determine a final strategy, feedback dates need to be set. This process takes place within the more general framework of the PNGMDR, which is reviewed every 3 years, thereby enabling stock to be taken of the measures implemented.

PNGMDR

The DSND was involved in the preparation of the new decree piloted by DGEC and the ASN, which resulted in the second version of the PNGMDR. Waste generated by defence-related nuclear installations and activities will be specifically mentioned, as in the law of 28 June 2006 on radioactive materials and waste management. Thus, the next decree, due to be published in 2011, will also need to be signed, like the law, by the Minister of Defence and the Minister for Industry.

The DSND was also involved in drafting the 2010-2012 version of the plan, which follows on from the first plan (2007-2009).

Containers in the solid waste storage workshop (EDS) in La Hague

As such, the DSND noted the progress made on issues such as recycling of metal or concrete waste produced during decommissioning in the nuclear industry. However, as recycling is a major aspect in terms of optimizing the use of disposal resources and capacity, the DSND considers that recycling of these materials should be subject to as broad an analysis as possible, without excluding a management channel in theory, provided that good "lines of defence" are put in place. These are based on:

– the historic traceability of the radiological conditions in which the material was placed, so that zones can be defined for any targeted clean-out needed;
– the outcome of non-contamination controls of such materials, so that they can be classified as conventional material;
– the traceability of first reuse.

The DSND also noted that the specifications for receiving waste in future repositories will not be available in the short term and reiterated that this meant that there was no guarantee as to the conditions in which the waste which operators were currently putting into storage would be accepted in the repositories being planned by ANDRA. Milestones need to be defined for establishing these specifications alongside the structural milestones set out in the PNGMDR for future installations.

The storage of tritiated waste from the "diffuse nuclear" sector for which there is no management channel was also raised. The DSND indicated that he had no objection to diffuse nuclear waste being accepted in SBNI storage, provided that its attributes are compatible with the standards of the installations in question, that it is limited in quantity and did not compromise the main purpose of these installations for defence activities and provided that these evaluation channels are defined, so as to guarantee that storage is indeed temporary.

Conclusion

The DSND has prepared regulations for the management of radioactive waste from SBNI which is absolutely in keeping with the principles set out in the Environmental Code. He monitors the application of them and ensures in particular that:
– waste processing and conditioning facilities are brought up to standard;
– legacy waste retrieval timetables are adhered to, especially where disposal channels exist;
– storage conditions of waste waiting for a disposal route are improved.

Progress still needs to be made in implementing disposal routes for certain types of waste and these topical issues will be addressed under the PNGMDR. ■

FRENCH WASTE MANAGEMENT POLICY: THE ROLE OF THE VARIOUS PLAYERS

Second version of France's National Radioactive Materials and Waste Management Plan

An ambitious roadmap for progress on sustainable radioactive materials and waste management

by Colette Clémenté, assistant director of transport and sources, Nuclear Safety Authority (ASN)

Under the 1991 Bataille law, which included provision for review in 2006, France endeavored, like most of its European partners, to introduce a management strategy for high level long-lived waste. Work on a National Radioactive Waste Management Plan, followed by a National Radioactive Waste and Recoverable Materials Management Plan (PNGDR-MV) started in 2003, at the recommendation of the Parliamentary Office for the Evaluation of Scientific and Technical Options (OPECST), with the aim of achieving a clear strategy and roadmap for managing all radioactive materials and waste.

It was clear from the outset that work which was intended to result in a national plan needed to include all the stakeholders, especially waste producers, political and administrative representatives, the organizations responsible for managing radioactive and non-radioactive waste and associations and stakeholders involved. As a result, a multidisciplinary working party was set up at the time to prepare the PNGDR-MV, first under the presidency of the Directorate General for Nuclear Safety and Radiation Protection, then, when it became the independent administrative Nuclear Safety Authority (ASN), under the joint presidency of the ASN and the Directorate General for Energy and Climate (DGEC).

This working party, which meets three to five times a year, prepared the first version of the PNGDR-MV in 2005. This was the version which was put to broad public consultation via the Internet.

The first version of the National Radioactive Materials and Waste Management Plan (PNGMDR), in keeping with the law of 28 June 2006, was sent to Parliament in 2007 and gave rise to a decree laying down the main requirements. This was when the milestones and deadlines were set in terms of radioactive materials and waste management and, more importantly, measures were taken to obtain a coherent plan for managing all types of radioactive waste produced. It also called for several studies, mainly from waste producers.

In 2007 and 2008, the multidisciplinary working party monitored the progress of the actions decided on in this first PNGMDR, then, in 2009, it decided to prepare a second version of the PNGMDR, which was finalized at the end of 2009, taking account of the results achieved since 2007, new problems that had arisen in the meantime and the opinion sent by the ASN to the Minister for Ecology on 25 August 2009 on the studies made in application of the decree setting out the requirements of the first plan.

So what has been achieved since 2007? This second version of the PNGMDR indicates that 90% of radioactive waste has a management channel. However, permanent solutions still need to be implemented for the remaining 10%. What progress has been made since the first edition of the plan? Where should efforts be focused now?

Storage: a necessary temporary solution which must remain temporary

Unlike repositories, storage facilities for radioactive waste are designed to serve a safety purpose for a limited time, rather than to serve a long-term safety purpose. Storage facilities for legacy radioactive waste are therefore subject to close scrutiny by the ASN, to ensure that operations to retrieve the waste or improve and strengthen the facility are planned in keeping with the deadlines set. Storage is needed until such time as the waste can be sent to a long-term management channel.

Is there sufficient storage capacity?

The correlation between storage capacities and predicted volumes of waste needs to be verified. However, the previous plan contained no data on storage capacities. In fact, it was designed before the national inventory of radioactive materials and waste was published by ANDRA in 2006. This inventory, which is published every three years, gives the total storage capacity on producers' sites (mainly La Hague, Marcoule and Cadarache for high and intermediate level long-lived waste), the capacities used up at the end of 2007 for the 2009-2012 inventory and, where necessary, the capacities planned to meet future requirements. Most new and extended storage requirements can now be anticipated. However, several scenarios for managing HL/IL-LLW need to be planned, especially the storage and retrieval deadlines and precise storage requirements remaining, in the run-up to the forthcoming public debate on the deep geological disposal project. The plan therefore requires ANDRA, in consultation with waste producers, to assess all the studies and research carried out into storage by the end of 2012.

These assessments supplement the regular evaluations by ASN of the radioactive waste management policies of the main nuclear operators (COGEMA in 1998, EDF in 2002, CEA in 2011).

Some low level long-lived waste (LL-LLW) generated by 'small' producers (outside the electronuclear industry) cannot be accepted by existing centres. This applies, for example, to waste produced during the clean-out of contaminated sites and

Table 1: Quantities (in m³) of radioactive materials declared at the end of 2007 and forecasts for the end of 2020 and 2030

		End of 2007	End of 2020	End of 2030
Natural mined uranium (tML)		27,613	32,013	32,013
Enriched uranium (en tML)		3,306	1,764	2,714
Uranium from spent fuel after processing (tML)		21,180	36,000	49,000
Depleted uranium (tML)		254,820	332,324	452,324
Thorium (t)		9,399	9,399	9,290
Suspended matter (t)		21,672	0	0
Fuel currently being used in nuclear power plants and in research reactors	UOX	4,500	3,860	1,100
	URE	80	290	0
	MOX	290	440	0
	Research	5		
Spent fuel awaiting processing	UOX (tML)	11,504	13,450	11,000
	URE (tML)	251	1 020	1,320
	MOX (tML)	1,028	2,320	2,550
	RNR (tML)	104	104	104
	Experimental fuels (t)	42	0	0
	Defence fuels	141	230	298
Plutonium from spent fuel after processing (tML)		82	55	53

radioactive objects held by private individuals. Sufficient storage capacity is needed for this waste which guarantees safety conditions which meet regulatory requirements pending a definitive disposal channel. In order to meet this requirement, ANDRA plans to construct a new repository for this waste at the VLLW repository in Morvilliers. This project relates to a very small volume of waste (approx. 4,500 m³). The plan requires this facility to be in industrial operation by the end of 2012.

Long-term management of recoverable materials

Some associations regret the lack of clarification in the previous plan between radioactive materials and radioactive

Sign banning access to the former Bellezane site

waste produced during the various stages of the fuel cycle, considering that there was no technical justification for classifying certain materials as recoverable and that this might force future choices in nuclear energy policy. There are large volumes involved, with no clear facility for routing them to an existing or planned long-term management channel.

Joint studies carried out by EDF-CEA-AREVA and RHODIA into the recovery of radioactive substances with no current use inventoried all materials held by operators in France and examined the recovery processes, with the aim of identifying materials for which no process would be available. They confirmed that materials produced by the "uranium" management channel and the "plutonium" management channel are recoverable, either now under current conditions of energy production (reprocessed plutonium and uranium) or in future in so-called fourth generation fast neutron reactors. If the project is carried out, these reactors will allow for recycling of plutonium and use of depleted uranium.

However, as indicated in the opinion of the High Commission for Transparency and Information on Nuclear Safety (HCTISN) dated 12 July 2010, this hypothesis "can be called into question at any time, depending on the technical, economic and political context".

As regards recovery of thorium materials held by the AREVA NPP, CEA and RHODIA, consistent research and development is still needed in order to resolve the technological problems which have arisen during process development and reactor design.

As a precautionary measure, the plan calls for the continuation of studies and recommends that the introduction of a mechanism to secure the long-term management of these substances be assessed.

Long-term waste management

Mining tailings: long-term monitoring plan

The problem of mining residues and site monitoring was studied in the previous plan and a series of actions planned in the decree of 16 April 2008 has been undertaken by AREVA. Mining residues with an estimated volume of 50 million tonnes are currently stored on 17 sites.

The disposal sites have been set up close to uranium ore processing facilities. The studies carried out by AREVA and submitted to the ASN at the end of 2008 provided detailed information on the classification of tailings and the behavior of the dykes enclosing certain disposal sites. However, the classification studies available do not cover all situations. AREVA will therefore submit a study by the end of 2011 to supplement the geomechanical assessments, so that the long-term safety of these repositories can be evaluated.

The radiological impact of repositories for processing residues appears to be seriously diminished where cover is designed based on the protective effect required. The plan requires AREVA to prepare a study by the end of 2011 on the feasibility and relevance of implementing covers and strengthening existing covers on all repositories for mining tailings. According to recent surveys relayed in the media, the public has serious expectations in this sector.

Mining sites have been subject to close scrutiny, resulting in the adoption of a 'Mining Action Plan' in 2009 by the Minister for the Environment and Sustainable Development and the ASN. The plan supports its recommendations in this sector and supplements them in terms, for example, of reducing the environmental impact of waste.

Conditions for waste rock reuse need to be evaluated

When uranium mines were first worked, the mining waste rock were offered to river authorities who might need material for banks[1]. Although the management of this material has been governed by the Mining Code since 1990, recycling of these materials in the environment may, over time, render use of the soil incompatible with the presence of such tailings. Also, the plan requires operators of old uranium mines, the most important of which is AREVA, to carry out an inventory of the sites close to the perimeter of old mines on which these waste rock have been recycled and to identify any incompatibility situations.

Naturally enhanced radioactive waste

The ASN has submitted an assessment of naturally enhanced radioactive waste management to the ministries, based mainly on two studies prepared by the Robin Hood association. Waste with the lowest levels of naturally enhanced radioactivity can be disposed of in conventional repositories (in application of the circular dated 25 July 2006 on the acceptance of naturally enhanced radioactive waste in conventional waste repositories), in the VLLW repository (CSTFA) or by internal waste disposal. Low level waste is generally put into storage on site as there is currently no operational disposal channel. The plan recommends a number of measures, including evaluation of feedback from the application of the circular dated 25 July 2006, an inventory of waste and a study by ANDRA of the availability of storage solutions for industries that occasionally produce naturally enhanced radioactive waste that would be destined for the future VLLW repository.

Optimizing the management of existing repositories: recycling certain very low level metal waste and finding permanent solutions for chemically complex radioactive waste

Large quantities of VLLW will be produced during decommissioning of nuclear plants already under way and in the future. According to the forecasts in the aforementioned national inventory of radioactive materials and waste carried out by ANDRA, 350,000 tonnes of very low level metal waste will be delivered to the dedicated repository in Morvilliers between now and 2030. At the end of 2008, 18% of the regulated authorized capacity had already been used. The plan calls on nuclear operators and ANDRA to take measures to save repository space, for example by studying technical solutions to compact waste delivered to the Morvilliers centre or by studying the feasibility of recovery management channels for certain VLLW in the nuclear sector.

Furthermore, some radioactive waste has physical and chemical properties that make acceptance in repositories more complicated. There is currently no management channel for such waste. The PNGMDR therefore requires ANDRA to study methods for managing this type of waste in light of the safety criteria adopted for disposal of LLW and the safety criteria adopted for disposal of "hazardous" waste within the meaning of the law.

Developing new long-term management methods

New management channels for tritiated waste and sealed radioactive sources

Tritiated waste and sealed radioactive sources were identified in the previous plan as radioactive waste for which management channels were still required. Article 4 of the programme law of 28 June 2006 on radioactive materials and waste management makes provision for tritiated waste ("the development by 2008 of storage solutions for waste containing tritium which allows its radioactivity to be reduced prior to surface or

Placing metal drums in a disposal cell at the Aube LILW disposal facility

1. Mining waste rock are materials (earth, rocks etc.) which are excavated in order to reach the uranium seam to be worked and which have not undergone mechanical or special chemical processing.

shallow underground disposal") and for radioactive sources ("finalization by 2008 of processes which allow used sealed sources to be disposed of in existing or future repositories").

The CEA submitted guidelines at the end of 2008 for the storage of tritiated waste with no management channel, the content of which was specified in the decree of 16 April 2008.

Storage of this waste would, in fact, appear to be necessary prior to dispatch to disposal channels. The project makes provision for facilities to be constructed to accept all solid tritiated waste produced up to 2060, the completion date for decommissioning of the ITER plant.[2] Thus, a storage solution of sufficient duration to allow the conditioned waste to decay and be dispatched to a disposal channel is planned for each family of tritiated waste. It is therefore up to the CEA to start constructing such facilities for its waste, on the basis of the guidelines submitted to the government.

Further study is needed for tritiated waste from the diffuse nuclear sector and for liquid and gaseous tritiated waste. ANDRA, in liaison with the CEA, is to submit proposals by the end of September 2011 on methods for taking charge of tritiated waste from the diffuse nuclear sector, an inventory of which has already been sent to the decay storage facilities. ANDRA, in liaison with the operators in question, will also need to consolidate the inventory of this tritiated waste from the diffuse nuclear sector by including objects and sealed sources in civil equipment (aeronautical, railway etc.) and defence equipment.

ANDRA submitted a study in December 2008 into processes which will allow used sealed radioactive sources to be disposed of in existing or future repositories. These sources are extremely varied (radionuclides, activities, forms etc.) and ANDRA has carried out an inventory of used sealed sources, in liaison with their main operators, in order to take account of this diversity. The IRSN provided its expertise for the purpose of this inventory. The ANDRA study sets out an initial guideline for the disposal of used sealed sources. With the exception of liquid and gaseous sealed sources, which cannot be disposed of in that form, the disposal channels proposed by ANDRA would enable used sealed sources to be accepted in their present state. Approximately 83% of the two million used sealed sources inventoried would therefore be destined for shallow underground disposal, 15% for surface disposal and 2% for deep geological disposal. Discussions between ANDRA and holders of sources need to continue, focusing, among other things, on ways of optimizing planning of used sealed source retrieval and collection and their compatibility with temporary availability of conditioning, storage and disposal channels.

New management channels for LL-LLW

Waste pending disposal includes radium-bearing waste generated mainly from processing minerals containing rare earth and graphite waste from the operation and future decommissioning of EDF natural uranium gas graphite reactors. The volume requiring storage is in the order of 200,000 m^3 of conditioned waste. ANDRA is studying the possibility of storage in shallow underground repositories (at depths of between 15m and 20m). At the end of 2008, around forty communes were prepared to study the possibility of providing such disposal. In 2009, two communes were chosen for geological investigation to verify the feasibility of this type of disposal. However, they pulled out.

2. The volume of tritiated waste is expected to reach 30 000 m^3 by the end of 2060, with radiological activity in the order of 35 000TBq.

New edition of the PNGMDR - June 2010

The State took note of these decisions and decided to allow more time for consultation. The plan sets out the framework for preselection of sites: the search for sites need to be based on candidates still competing, with a view to finding exemplary sites from the point of view of both nuclear safety and consultation and transparency, while respecting the principle of voluntary agreement by the local authorities. A public debate will be organized before the site is chosen. The plan requires a study into the possibility of storing certain bitumen-conditioned effluent with certain radium-bearing and graphite waste. The model for dimensioning the repository has yet to be proposed and is a key point of the project. ANDRA and waste producers need to pursue technical studies in the processing, behavior and conditioning of waste.

HL-LLW and IL-LLW: research continues

Significant progress has been made since the previous plan in moving towards the creation of a deep geological repository for HL-LLW and IL-LLW. A restricted interest zone for in-depth research (ZIRA) as a site for the future repository has been approved by the government. The plan requires ANDRA to prepare a dossier in 2012 to support the public debate. The public debate, which may take place at the end of 2012, will present the proposed choice of site before the repository is commissioned in 2025.

Research carried out in the Meuse/Haute-Marne underground laboratory has confirmed the radionuclide confinement properties required of the geological formation. Since the plan was adopted, the National Assessment Board (CNE) has stated that a validated operational model of the hydro-mechanical behavior of the rock is needed in order to predict changes in the behavior of works and their consequences in terms of safety and reversibility.

This repository must be designed so that it can be closed and remain safe following closure, even if it is forgotten about. At present, all research is being carried out in the Meuse/

Haute-Marne underground laboratory, which will need to remain operational for several years after the repository has been opened.

In addition, ANDRA will submit a summary at the end of 2012 of research carried out in liaison with producers into innovative solutions which improve the complementarity between storage and disposal (storage facilities could be integrated into the disposal facility).

Separation and transmutation

Separation/transmutation of radioactive elements is one of the possibilities which the CEA has been asked to study for the purpose of HL-LLW management. The aim is to reduce radiotoxicity owing to the presence of long-lived elements and the thermal load in final waste for deep storage. Final development will involve developing a prototype (Astrid) to prepare for the industrial launch of future (4th generation) reactors which can demonstrate and validate the possibility of transmuting minor actinides at scale 1. The 2006 law makes provision for this prototype to be commissioned in 2020.

The plan requires the CEA to submit an evaluation of the industrial prospects for fast reactors by 2012. The advantages and disadvantages of separation/transmutation will need to be clarified in order to evaluate the input of these techniques. A global feasibility review for new generation reactors by the CEA will also provide new information in 2012.

Waste knowledge and conditioning

The plan calls for studies to continue into adapted conditioning for IL-LLW, especially legacy IL-LLW, which the law of 28 June 2006 requires to be conditioned by 2030. It suggests that research should be started to implement new conditioning processes for certain types of technological waste containing organic or irradiant materials or rich in alpha emitters.

This new version of the PNGMDR contains a complete inventory of radioactive waste produced in France and the management channels available or to be developed for it.

The Environment Round Table commitments to promote recycling triggered real momentum in numerous industrial sectors (construction, aviation, automotive). In the nuclear sector, the question is still complicated, but progress is possible. The plan therefore calls on operators to study the implementation of waste recovery management channels in the nuclear sector. Another way forward for the purpose of management is to develop fourth generation reactors which allow certain materials (such as depleted uranium) to be recycled.

Since the previous version (2007), new management channels have been identified for waste which previously had no management channel. This applies, for example, to tritiated waste and used sealed sources. These now need to be implemented, but there is still a long way to go.

Lessons still need to be learned in certain areas. For example, lessons need to be learned from the failed procedure initiated in 2008 to create a repository for LL-LLW and the procedure needs to be restarted on a different basis so that it is ultimately acceptable to everyone.

In-depth engineering studies have started for the purpose of designing a safe, reversible deep repository for IL-LLW and HL-LLW, so that all the necessary information will be available when the application for authorization is submitted. Clear progress has been made with this project, having reached the milestones laid down in the PNGMDR, especially examination of the dossier submitted by ANDRA in 2009 in accordance with the PNGMDR decree of 16 April 2008. The plan contains recommendations for the roadmap for this project by suggesting dated and quantified targets.

The future of waste which still cannot be allocated to an existing or planned management channel also needs to be considered ("no management channel" waste), so that it can be allocated to a long-term management channel. A working party piloted by DGEC and involving ANDRA, the ASN, the IRSN and waste producers has already been set up to propose solutions and provide input for the next plan.

Finally, efforts to provide information accessible to everyone need to continue; even though the High Commission for Transparency and Information on Nuclear Safety welcomed the new plan, which it sees as a genuine reference tool for radioactive waste, it recommended that "each new version of the PNGMDR should be debated in Parliament, with a view to comparing the opinions of all the players involved in the acquis and outlook in the waste cycle and management sectors".

The aim of the PNGMDR is obviously to ensure that everyone has an overall view of the radioactive waste produced, regardless of origin, to guarantee that its safe management is taken into account and to prioritize the work needed. France was the first country to introduce this type of plan and the French plan could be used as an example, given that the proposal for a European directive on radioactive waste currently being prepared has adopted the same principle and proposes that each Member State should be asked to prepare such a plan. ■

Références

[1] : Opinion no. 2009-AV-0075 by the ASN dated 25 August 2009 on the studies submitted in application of decree no. 2008-357 of 16 April 2008, issued in application of Article L.542-1-2 of the Environment Code, setting out the requirements for the PNGMDR.

Gallery of the Bure laboratory

FRENCH WASTE MANAGEMENT POLICY: THE ROLE OF THE VARIOUS PLAYERS

ANDRA, the key player in radioactive waste management

by Marie-Claude Dupuis, director general, National Radioactive Waste Management Agency (ANDRA)

Controlled and sustainable radioactive waste management is needed in order to protect present and future generations from the risks inherent in it. The State has set up an agency to address this (National Radioactive Waste Management Agency) and adopted specific legislation governing all waste management-related activities.

ANDRA, which has been a public industrial and commercial institution since 1991, is responsible for proposing and implementing a set of industrial management channels which will guarantee controlled and coherent management of all French radioactive waste.

ANDRA currently has a staff of just under 450 employees spread across 5 sites:
– two repositories in operation in Aube;
– one repository under supervision in the Management channel;
– one centre for studying deep disposal in Meuse/Haute-Marne;
– its headquarters in Hauts-de-Seine.

Since being set up as an independent agency, ANDRA has continued to develop dialogue and consultation, in a bid to meet the challenges imposed on it, without compromising transparency. It has therefore developed strict and exemplary industrial activities, in liaison with waste producers and the authorities, in a bid to protect man and the environment in the long term. The Agency is currently preparing to meet new challenges: to preserve rare repository resources, to build the first deep repository in clay, to restart the procedure for LL-LLW suspended in 2009 and to optimize management channels.

As a key player in radioactive waste management in France, ANDRA continues to develop and affirm its unique expertise, which is recognized both in France and internationally.

Missions governed by law and the National Radioactive Materials and Waste Management Plan

The 1991 Bataille law[1] made ANDRA an independent public agency supervised by the ministers responsible for environmental affairs, energy and research. In 2006, a new law[2] set out ANDRA's mission: to find, implement and guarantee

1. Law no. 91-1381 of 30 December 1991 on research into radioactive waste management.
2. Law no 2006-739 of 28 June 2006 on radioactive materials and waste management.

Table 1: Volumes (in m³)* of radioactive waste in storage or repositories at the end of 2007, and anticipated volumes at the end of 2020 and 2030

	2007	2020	2030
VLLW	231,688	626,217	869,311
LL-SLW and IL-SLW	792,695	1,009,675	1,174,193
LL-LLW	82,536	114,592	151,876
IL-LLW	41,757	46,979	51,009
HLW	2,293	3,679	5,060
Management channel pending **	1,564	-	-
Total	1,152,533	1,804,142	2,251,449

(Source: ANDRA 2009 National Inventory of Radioactive Materials and Waste)

*Quantities of radioactive waste are presented in equivalent cubic meters conditioned (m³), i.e. the volume of each type of waste following conditioning.
**This waste is declared by producers without being allocated to an existing or planned management channel, either because they are in a form that prevents allocation to a management channel or because no processing method is currently planned.

safe management methods for all French radioactive waste. In order to secure funding for waste management while adhering to the "polluter pays" principle, this law requires funding directly from radioactive waste producers, in proportion with the volumes they produce (in the form of contracts with ANDRA for existing repositories or a tax in addition to the tax on basic nuclear installations for research under way. Finally, ANDRA receives an annual grant from the State for its public service mission, especially in terms of taking charge of legacy waste.

The Agency's activities are governed by the National Radioactive Materials and Waste Management Plan (PNGMDR), which is updated by the State every three years. This plan sets out the implementation of industrial management solutions and research and studies needed for planned management channels. The PNGMDR 2010-2012 consolidates ANDRA's role in designing and operating repositories and extends its remit upstream of disposal, by encouraging it to be pro-active in optimizing radioactive waste management, in liaison with waste producers. Similarly to the 2006 laws[3], the PNGMDR 2010-2012 highlights the need for ANDRA to conduct its activities without compromising transparency, dialogue and consultation.

National inventory: an essential management tool

In order to be in a position to implement coherent and exhaustive management of all French radioactive waste, ANDRA establishes and updates a national inventory of radioactive materials and waste every three years, on the basis of statements made by waste producers or holders. In addition to the role it plays in terms of information, this inventory is vital to the management of radioactive waste, firstly, because it provides information in complete transparency on all existing materials and waste by stock and location and, secondly, because it provides structured information by management channel. Finally, it provides forecasts of future volumes of waste, thereby enabling future needs to be anticipated and optimum dimensioning of repositories.

The 2009 version of the national inventory identifies nearly 1,153,000 m³ of radioactive waste over more than a thousand sites in all sectors.

Today, nearly 90% of French radioactive waste has an operational management channel. For several years, ANDRA has been piloting studies and research in order to design innovative industrial solutions for the 10% of waste for which there is currently no definitive management channel. For all this waste, commissioning operational, safe and economically optimized long-term management channels will be a major challenge for ANDRA over coming years.

Only a small volume of waste (around 1,600 m³) currently has no identified management channel, due to specific physical or chemical properties (e.g. degassing tritiated waste, asbestos waste, chemically reactive waste, such as waste impregnated with caustic soda, or certain used sealed sources).

There are currently three levels of development for the various radioactive waste management channels (Table 2).

Reference industry

At the end of 2007, over 70% of waste produced was already in repositories in ANDRA centres. This was all VLLW or LL-SLW and IL-SLW.

La Manche Repository (CSM)

The La Manche repository was the first radioactive waste repository created in France for LLW and ILW. When it was created in 1979, ANDRA took over the management of it pending its closure. Between 1969 and 1994, approximately 527,000 m³ of waste was stored there. The repository was covered with an airtight cover and has been in the surveillance stage since 2003 (for approx. 300 years). ANDRA has started a gradual approach towards a permanent cover that will provide a passive guarantee of the long-term safety of the repository, mainly thanks to the gentler gradients.

LLW and ILW repository (CSFMA)

ANDRA has been operating the surface repository for LLW and ILW in Aube (CSFMA) since 1992. The CSFMA is a basic nuclear installation authorized to accept 1 million m³ of LL-SLW/IL-SLW, mainly operating and maintenance waste from nuclear power plants. Packaged waste is delivered ready for storage or conditioned on site and disposed of in

3. Law no. 2006-739 of 28 June 2006 on radioactive materials and waste management and Law no. 2006-686 on transparency and safety in the nuclear sector.

Table 2: Volumes (in m³) of radioactive waste in storage or repositories at the end of 2007 and anticipated volumes at the end of 2020 and 2030

Management channel		Type of waste
Definitive management channel exists	Surface repository for VLLW commissioned in 2003 (CSTFA)	VLLW
	Surface repository for LLW and ILW commissioned in 1992 (CSFMA)	LL-SLW/IL-SLW
Definitive management channel being studied	Cigéo project (deep repository)	HL-LLW and IL-LLW
	Shallow repository	LL-LLW
	CEA and ANDRA projects (storage for decay prior to disposal in appropriate management channel)	Tritiated waste
	Guideline criteria proposed for four disposal channels (existing or being studied)	Sealed sources
As yet no management channel	-	Waste with no management channel *

*Waste identified in the 'no management channel' category (approx. 1 600 m³) is waste declared by producers which cannot be allocated to a management channel. There are two possible cases: either their physical or chemical form is such that they cannot be allocated to a management channel and no processing method is planned at present or there is insufficient knowledge of the waste at present, in terms of its physical and chemical properties (mainly legacy waste), to define the best management channel.

An information- and dialogue-based approach

Radioactive waste management is a general topic of concern and public debate. In order for everyone to understand the trends and tendencies and be able to form an opinion, ANDRA has to provide clear and comprehensible information. For example, it offers various information outlets, such as the website on radioactive waste set up recently at (www.dechets-radioactifs.com) and organizes information-giving events for the public (open days, visits etc.).

It is impossible to construct and operate repositories nowadays without engaging closely with the local inhabitants (neighbors, elected officials, local information committees, associated or economic operators etc.). ANDRA has no wish to limit consultation to its statutory obligations and has started a process of in-depth dialogue and consultation with these operators in order to satisfy their demands and take account of their expectations. ■

reinforced concrete cases (25 meters x 25 meters by 8 meters high). At the end of 2009, approximately 231,000 m³ of packaged waste had already been disposed of at CSFMA, i.e. 23% of its authorized capacity.

VLLW repository (CSTFA)

ANDRA has operated the VLLW repository (CSTFA), which is also in Aube, since 2003. The CSTFA is a classified installation which seeks to protect the environment. It is designed to hold 650,000 m³ of VLLW, especially waste from decommissioning nuclear installations. The packaged waste, which is inspected on arrival, is disposed of in cells hollowed directly out of the clay. At the end of 2009, approximately 143,000 m³ of VLLW had been disposed of at CSTFA, i.e. 22% of its authorized capacity.

The ANDRA repositories are an international technological benchmark. Experience from the La Manche repository, one of the very first surface repositories in the world, and from the repositories in Aube has provided specific lessons for all countries working on radioactive waste management.

New challenges for ANDRA

To preserve rare repository resources

Radioactive waste repositories are rare resources, with limited capacity that needs to be preserved. Reducing volumes of waste is therefore one of the main concerns of all operators in this sector.

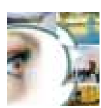
Numerous research projects carried out in the electronuclear sector over the past 20 years have already enabled volumes of waste to be reduced, via various specific measures such as reducing potential waste at source or modifying the methods used to process and optimize conditioning. These different measures have already allowed consignments delivered to the VLLW repository to be reduced over several years, thereby prolonging its lifetime with no change in capacity.

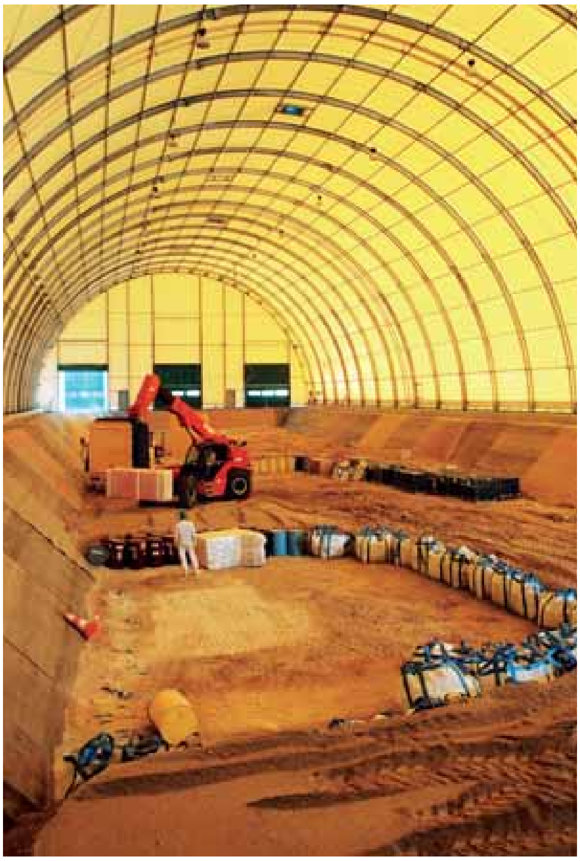
On the other hand, the repository space in the VLLW repository is filling up faster than expected. The PNGMDR 2010-2012 calls on the various operators to take steps to reverse this trend, which include studying recycling of metal VLLW in the nuclear sector. The State has also given funding to ANDRA to develop innovative solutions under the Future Investment Programme.

To prepare the construction of the first deep repository in clay

The law of 28 June 2006 validated the work carried out by ANDRA since 1991, confirmed deep reversible disposal as the reference solution for HL-LLW and IL-LLW and set new deadlines for the Agency to allow such a centre to be commissioned in 2025. The law also made provision for the application for authorization to create the repository, which must be submitted by the end of 2014, to be preceded by public debate (in theory at the end of 2012).

ANDRA filed its proposals for the location and design of the 'Cigéo' industrial geological repository at the end of 2009. An important step in the project was taken when an interest zone for underground repositories was defined and validated by the government in March 2010.





Placing VLLW (very low-level waste) in "big bags" into a disposal cell which was excavated a few meters deep into the clay rock

The 2009 milestone was also an important step in the gradual process of designing the repository. Following the iterations in 1998, 2001 and 2005, predicated mainly on the long-term safety of the repository, the 2009 dossier emphasized its operational safety, which needs to take account of the atypical properties of an underground BNI. It also integrated initial results from the repository optimization studies carried out in 2006, which are continuing in the wake of the project. It provides a basis for defining, in liaison with producers, the scope of the first operational tranche in the repository.

The opinion due to be submitted shortly by the Nuclear Safety Authority on the options presented will enable ANDRA to continue its work to prepare the application for authorization to create the repository, so that construction of Cigéo can start in 2017. In order to guarantee the success of the project, ANDRA will need to strike a balance between safety, reversibility, local integration and cost management, knowing that Parliament will rule on the reversibility conditions in around 2016.

To resume the work suspended in 2009 for LL-LLW

In 2008, ANDRA launched a call for expressions of interest from municipalities whose land is potentially geologically suitable for a repository for this type of waste. At the end of 2008, around forty communes had filed expressions of interest. Two communes were selected by the Government for in-depth investigation of their territory, but they withdrew from the project during the summer of 2009 under pressure from opponents.

ANDRA regrets that it was not possible to bring this innovative approach to find a site, based on progressiveness, dialogue and consultation, to a close. It is important for everyone to know the reasons. That is why the High Commission for Transparency and Information on Nuclear Safety set up a working party, which is due to file its conclusions in 2011, in order to clarify what happens next.

At the same time, the State has suspended the time constraints for developing disposal solutions for LL-LL waste in the PNGMDR 2010-2012. ANDRA has been asked to re-open the various technical options and to continue its studies into the knowledge, behavior and processing of the waste in question. All the scenarios should be ready by 2012. The report to be submitted to the Government will contain an analysis of these scenarios, based on various criteria (safety, social acceptance, cost, technical/economic viability etc.).

To optimize management channels

Thanks to a radioactive waste management policy applied in France for several years, 90% of the volume of radioactive waste produced in France has an operational disposal channel and management channels are planned or being designed for the remaining ten per cent. Although this situation is overall satisfactory, it should not be forgotten that waste management represents a burden on society (economic cost of management, difficulty in finding sites for repositories or the radiological impact of waste processing and disposal facilities, even if it is kept to very low levels).

As the agency responsible for the final disposal channel of radioactive waste, ANDRA is keen to take an active part in discussions involving all operators in the industry to optimize waste management. In fact, ANDRA considers that developing collective practices towards greater technical, economic and social efficiency, in compliance with safety requirements, is one way of implementing its public service mission. ■

The role player by the National Assessment Board

by Jean-Claude Duplessy, chairman of the National Assessment Board (CNE)

Background

At the end of the 1950s, France developed a civil nuclear industry and opted to process the spent fuel. Processing installations allow the uranium and plutonium, which can be re-used in new fuel, to be separated from fission products and minor actinides (HL-LLW currently conditioned in the form of borosilicate glass). Processing also generates process waste, some of which is sufficiently contaminated with long-lived elements as to require specific disposal (IL-LLW).

Whereas low level or intermediate level waste containing short-lived elements (< 30 years) is now disposed of in surface repositories in Aube and La Manche, long-lived waste is currently stored temporarily until a permanent solution can be found.

In 1979, long-term management of radioactive waste was assigned to a specialized agency created within the Atomic Energy Commissariat (ANDRA). Between 1987 and 1989, ANDRA started a programme of research into HL-LLW based on geological disposal and studied the possibility of setting up an underground research laboratory in four *départements*. In 1990, in the face of opposition from the local inhabitants, the Government announced a moratorium on studies and research into radioactive waste management and referred the matter to Parliament. Following consultation headed by Christian Bataille MP, the law of 30 December 1991 set out guidelines for the research programme to be carried out, in which three axes were defined:

1. research into separation and transmutation of long-lived radioactive elements present in this waste;

2. study into the possibility of reversible or irreversible deep geological disposal, mainly in underground laboratories;

3. study into surface conditioning and long-term storage of waste.

The 1991 law requires the Government to send Parliament an annual progress report on this research. Parliament then consults the Parliamentary Office for the Evaluation of Scientific and Technical Options. The law requires this report to be drafted by a national committee comprising:
– six qualified persons, at least two of whom are international experts appointed by the National Assembly and Senate on the proposal of the Parliamentary Office for the Evaluation of Scientific and Technical Options;
– two qualified persons appointed by the Government at the proposal of the Supreme Nuclear Safety and Information Council;
– four scientific experts appointed by the Government on the proposal of the Academy of Sciences.

In order to carry out its assessment work, the committee hears the bodies in charge of implementing the research programme set out in the law. In order to support scientific exchanges on this multidisciplinary work, all the operators involved attend each hearing. ANDRA, which pilots the second axis, and the CEA, which pilots the first and third axes, are the two pillars of this approach.

The national committee set up under the Bataille law, since renamed CNE1, published 11 annual reports between 1995 and 2005 and a global report in 2006 summarizing the fifteen years of research carried out under the law.

In 1998, CNE1 also produced a specific report, at the Government's request, on the subject of reversibility.

In 2006, at the end of a fifteen-year period, the Government sent Parliament an overall research evaluation report based on the dozen reports and opinions produced by CNE1, accompanied by a bill authorizing the creation of a reversible repository for HL-LLW and setting out the system of easements and constraints applicable to the centre.

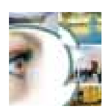
Scientific acquis 1991-2006

The Bataille law gave scientists huge scope to research the problems mainly studied, before 1991, by the restricted nuclear community. The knowledge acquired over the course of the next fifteen years enabled long-lived radioactive waste management to be set on a solid scientific basis, even if not all the research has reached the same level of maturity.

The overall report drafted by CNE1 in January 2006 underlined the following points:

■ Axis 2

– Research under axis 2 into reversible deep geological disposal is the most advanced and is the reference method for definitive management of final waste. It therefore needs to be studied through to the end. ANDRA published a dossier in June 2005 describing all the results obtained since the law was promulgated in 1991, for both granite and clay.
– The 2005 Granite dossier evaluates the possibility of deep geological disposal in granite. With no designated site, ANDRA has worked on a generic basis. Its studies have been carried out on several massifs in France and by participating in numerous international experimental programmes to study the possibility of disposal in granite (Sweden, Finland, Switzerland and Canada). The report indicates that the quality of a granite site for disposal depends primarily on its fracturing.
– The 2005 Clay dossier explains the research carried out around the Bure site and in the underground laboratory. The geophysical studies and numerous test drillings carried out (several kilometers of cores and logs) have provided an exceptional crop of results. The experiments and observations carried out underground started in the autumn of 2004. At the end of two years, they were still at a preliminary stage, even though a large number of results were already available. The image of the properties of the geological formation coming out of these investigations is, without doubt, a favorable image.
– CNE1 recommended that the research required in order to



make an informed decision should continue after 2006. This research should focus on two very distinct objectives: firstly, the operation of an underground laboratory to validate the site and, secondly, research into a suitable location for surface disposal measuring 10 to 20 km^2 within a larger 200 km^2 zone (transposition zone).

■ Axis 1

– The objective of research under axis 1 is to reduce the radio toxicity of HL-LLW generated from current processing, due to long-lived radionuclides contained in the spent fuel.
– CNE1 has emphasized that reducing radiotoxicity by separation/transmutation involves serious modifications downstream of the current fuel cycle, in order to reduce the presence of long-lived radionuclides in the waste. It will be necessary to separate from the spent fuel both the plutonium and uranium (which is already being done) and the minor actinides and certain fission products and then to transmute the long-lived radionuclides contained in them.
– The scientific feasibility of separating minor actinides, technetium and iodine has been demonstrated. Research into hydrochemical separation carried out by the CEA has advanced to the point where it can be developed by later studies, as and when necessary.
– In order to demonstrate the scientific feasibility of transmuting actinides, basic physical data is needed, especially for the heaviest radionuclides, in order to assess precise transmutation performances in the reactor.
– The technical feasibility of transmutation has not yet been demonstrated and will need to show that significant quantities of transmutation materials can be left in the reactor for a long time. The partial experiments already carried out into minor actinides are merely illustrative. A complete demonstration will need to show that irradiated materials can be processed in order to recycle the actinides not transmuted. No experiments along these lines have yet been carried out.
– CNE1 recommended that the objectives of separation in relation to the potential objectives of transmutation should be defined for after 2006 and that materials should be developed which will allow new fuels or targets to be developed for transmutation in rapid reactors. Given the scope of the research needed, CNE1 also recommended that it should be carried out within an international cooperative.

■ Axis 3

– The objectives of research into axis 3 concerns conditioning of HL-LLW and IL-LLW both for disposal and long-term storage of conditioned waste, either on the surface or in the subsurface (request formulated by the Government in 1998 over and above the law).
– CNE1 noted that industrial conditioning of processing or other waste resulted in primary packages of HL-LLW and IL-LLW. Storage of these packages is carried out on an industrial scale without issues on storage sites designed to operate for fifty years. The same applies to experimental packages of spent fuel stored in pools and some experimental packages stored in the dry.
– Industrial conditioning of IL-LL processing waste has made significant progress in ten years in terms of reducing volumes and the activity of effluent released into the environment by the factory in La Hague has been reduced considerably. These studies also demonstrated that the radionuclides in IL-LLW could not be recuperated and transmuted and are final waste.
– Only research into storage of packages of reprocessing waste by renewing the most recent industrial storage has been completed. It indicates that safe storage can be planned for periods in the order of a hundred years. As far as longer storage on the surface or sub-surface in new types of storage is concerned, only theoretical sketches and preliminary studies have been proposed.

Drums of ILW-LL waste

– CNE1 recommended that studies into waste conditioning should continue after 2006, into both disposal and long-term storage, emphasizing that two types of research are needed: basic research into the behavior of waste packages and more technological, engineering research into containers and warehouses.
– Finally, CNE1 emphasized that, if the option of storage for several centuries were to be considered, research also needed to continue into containers, especially concrete containers, and into civil engineering materials for warehouses, in order to guarantee that the period of integrity of the containers is at least equal to that of the warehouse.

Thus, in early 2006, the CNE considered that the research carried out enabled the authorities to plan a long-term radioactive waste management strategy (HL-LLW and IL-LLW) and to set objectives, allocate resources and establish timeframes.

The 2006 law and its implementation

The law of 28 June 2006, which is more general that the law of 1991, concerns the sustainable management of all radioactive materials and waste.

In order to ensure the management of long-lived (high level or intermediate level) waste, the law stipulates that research and studies into this waste are to be carried out under three complementary axes:

■ **Séparation-transmutation** of long-lived radioactive elements: the corresponding studies and research will be carried out in tandem with those into new generations of nuclear reactors and reactors piloted by dedicated waste transmutation accelerators;

■ **Reversible deep** geological disposal: studies and research should enable a site to be selected and a repository to be designed.

The application for authorization is to be examined in 2015. Subject to authorization, the repository could be operational by 2025;

■ **Storage**. research and studies are being carried out to create new storage facilities or modify existing installations and to address questions of capacity and duration.

The Government appointed the CEA to pilot axis 1 and ANDRA to pilot axes 2 and 3. Plans have been made to involve university teams in the two pilots and the CNRS has implemented the Programme downstream of the cycle and nuclear energy production (Pacen), coordinating the work of the six national research groups and four joint research programmes (internal CNRS structures) to investigate, from a very upstream perspective, the options which do not come under the current national strategy.

The legislature sought to continue the work initiated under the 1991 law and set up a committee under the law of 28 June 2006 to carry out an annual progress assessment of research and studies into radioactive materials and waste management.

The decree of 7 April 2007 set up this new committee (referred to as CNE2) which, although very similar to its predecessor, was not a carbon copy of it.

Firstly, its composition was changed. Although it still had a maximum of twelve members, two of them were now appointed at the proposal of the Academy of Human and Political Sciences, and the other ten were appointed, as in CNE1, on the proposal of the Academy of Sciences and the Parliamentary Office for the Evaluation of Scientific and Technical Options. This change was in response to a remark by CNE1 in its 2005 report, in which it regretted that fields of research such as economics and sociology were not addressed, because it had no such specialists.

The presence of an economist and a sociologist would allow work carried out in the human sciences to be assessed because, obviously, the problems raised by nuclear waste were not merely scientific and technical questions.

Like CNE1, CNE2 is an independent committee, free to act and give opinions at its discretion. Its area of competence is set out in the 2006 law, in that its assessments now need to be carried out "with reference to the approaches set out in the National Radioactive Materials and Waste Management Plan (PNGMDR)".

Major objectives over the years to come

Future research and the direction given to it in the 2006 law seeks to achieve specific results. This change is marked by a precise definition of families of waste, a set timetable and a direct link between each achievement and the subsequent steps. Research into primary conditioning of legacy or miscellaneous waste is now the responsibility of the producers.

Studies into geological disposal are now entering a decisive phase; the Minister for Ecology, Energy and Sustainable Development has approved the option proposed by ANDRA of an interest zone for in-depth reconnaissance (ZIRA) with a view to installing reversible geological disposal. ANDRA therefore has a fixed timetable: dossier to be submitted at the end of 2012 to support public debate, followed by an application to create a repository at the end of 2014 so that it can be examined in 2015.

Studies into separation/transmutation follow on from the studies carried out in order to design the Astrid prototype (4th generation fast reactor). In order to demonstrate the feasibility of the separation/transmutation strategy, multirecycling of the plutonium and minor actinides using Astrid and pilot processing will need to be demonstrated, in order to prove that a fuel cycle associated to a transmuting rapid reactor can be closed on an industrial scale. The CEA is due to present a report at the end of 2012 into the prospects of separation/transmutation on an industrial scale.

Given the milestones set for 2012, the next three years mark a decisive phase in the implementation of the 2006 law. CNE2, which is required to assess all the research carried out by the players named in the law, will ensure that it helps to achieve the objectives set by the legislature. ■

FRENCH WASTE MANAGEMENT POLICY: THE ROLE OF THE VARIOUS PLAYERS

The work of the High Commission for transparency and information on nuclear safety concerning the management of radioactive materials and waste

by Henri Revol, chairman of the High Commission for Transparency and Information on Nuclear Safety (HCTISN)

The High Commission for Transparency and Information on Nuclear Safety, which I have the honor of chairing, was established on 18 June 2008, in the presence of the Minister for Ecology, Energy, Sustainable Development and the Sea, Jean-Louis Borloo.

The Commission was created under the law of 13 June 2006 on transparency and nuclear safety as a consultative body for information on nuclear activities, their safety and their impact on public health and the environment. In addition, Article 10 of the programme law of 28 June 2006 on the sustainable management of radioactive materials and waste requires the High Commission to organize periodic consultation and debate on the sustainable management of radioactive materials and waste.

The sustainable management of radioactive materials and waste is therefore one of the topics of major interest to the High Commission. That is why the High Commission initiated a round of meetings in 2009 on the subject of radioactive waste management, following which it decided to set up a think tank on information, consultation and transparency in connection with the procedure to establish a LL-LLW repository. This working party, which was set up in early 2010, is steered by Mrs. Saida Laârouchi-Engström, director of the Department of Environmental Impact Studies and Public Information of SKB[1] (Sweden, which provides experts to the High Commission). The objective of this think tank is to propose recommendations to support the government approach, so that this process can continue.

In terms of working method, the working party opted to organize hearings or interviews with the people involved in the choice of a repository and to organize a move to Aube, where the ANDRA CSA repository is located. The working party also works closely with the working party of the National Association of Local Information Committees and Commissions (ANCCLI) in order to obtain input. Finally, it reports regularly on the progress of works at plenary meetings of the High Commission.

Radioactive waste management was also the subject of extensive and in-depth debate in the High Commission when the report was drafted on transparency in the management of materials and waste produced at various stages in the fuel cycle. This report follows on from referrals by the Minister and the Parliamentary Office for the Evaluation of Scientific and Technical Options (OPECST) dated 16 October 2009 and 4 November 2009. This report was officially submitted on 12 July 2010.

This unedited report contains a detailed analysis of the fuel cycle as it currently stands in France. It indicates the flows and stocks of materials and waste produced at the various stages of the fuel cycle and the conditions for storage and transportation of spent uranium and uranium produced from the processing of spent fuel for recycling, and sets out the implications in connection with uranium supplies and France's policy to secure supplies within the international context. It also relies on the National Radioactive Materials and Waste Management Plan (PNGMDR) established in application of the programme law of 28 June 2006 on the sustainable management of radioactive materials and waste. The last part of this report is devoted to the quality of the information provided to the public. Thus, the High Commission has established that:

– the management of materials produced during the fuel cycle comes within the framework of an international market based on standard practices;

– some of these materials are not yet efficiently recovered and are put into storage for such an eventuality (given the prospects for recycling and the fact that, under the law of 28 June 2006

HCTISN report published in July 2010

1. Swedish company that manages radioactive waste from NPP operations.

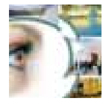
on the sustainable management of radioactive materials and waste, uranium for recycling and depleted uranium are currently classified as recyclable radioactive materials;
– the classification of materials/waste is not definitive and may be revaluated in light of the industrial, political and/or technical/economic context;
– information on shipments of materials abroad, especially to Russia, is not classified;
– information and documents dealing with these issues, even if freely available on the Internet, are hard for the public to access and some information released by nuclear operators may have given rise to the impression that there is a cycle in which all the materials generated by processing spent fuel are recycled immediately, without clearly explaining the limitations on the integral recycling of processing waste.

Having established this and aware that information intended for the public should be easily accessible and comprehensible, the High Commission formulated recommendations designed to improve the transparency and quality of information provided to the public. They included increasing public awareness of the PNGMDR, as a genuine reference tool, and organizing debates upon each release of a new version of the PNGMDR, in order to regularly compare the point of view of all the operators involved in the acquis and prospects in the fuel cycle and waste management sectors.

Finally, two and a half years after it was established, we must admit that, whatever the topic examined by the High Commission, questions relating to radioactive waste management are unavoidable and constantly give rise to individual studies, discussion and debate within the High Commission.

In 2011, the High Commission hopes to organize consultation and debate on the sustainable management of radioactive materials and waste, in application of the provisions of Article 10 of the programme law of 28 June 2006 on the sustainable management of radioactive materials and waste and to ensure that that these debates can be followed by the public and the press and are not necessarily confined to colloquia between specialists.

In conclusion, may I remind you that, ever since it was established, the High Commission has taken a dual approach, by listening to the public's expectations and reacting to current events. The collegial structure of the High Commission, which has around forty members in 7 colleges, encourages members to express and compare their different points of view which, even if contradictory, are always respectful of others' sensitivities. This attitude is clearly one of the factors which encourages the members of the High Commission, sometimes by sacrificing their free time, to become involved in the various tasks initiated and I thank them for this. ■



SAFETY OF RADIOACTIVE WASTE MANAGEMENT FACILITIES: INSPECTIONS

Radioactive waste storage at the CEA Centre in Cadarache

Transfer from the "storage yard" to the CEDRA facility: an illustration of changes in the safety requirements

by **Ghislaine Verrhiest-Leblanc**, project manager, and **Christian Tord**, assistant to the Head of the Marseille Division of the Nuclear Safety Authority (ASN)

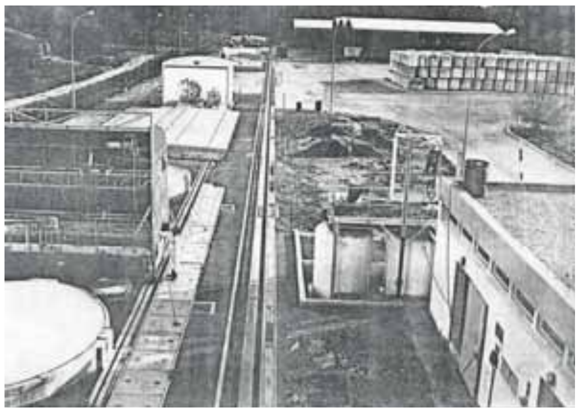
Since the first nuclear installations were built in France in the 1960s, the storage and disposal strategy has evolved. Some installations initially dedicated to disposal have seen their status changed to storage zones, in the wake of technical progress and policy changes in their sector. Today, at the request of the Nuclear Safety Authority (ASN), these installations which no longer meet current safety requirements are in the process of being decommissioned and the waste is being transferred to new storage sites pending transfer to final disposal channels.

Cadarache Centre storage yard trenches: a heavy legacy

This applies to the storage yard (BNI 56) at the Cadarache Centre. This installation, which was commissioned in 1969 (photo opposite) was initially intended as a repository for solid waste and was referred to as the "disposal yard". The main disposal zones consisted of various types of trenches and ditches (the trenches are described below by way of example). In 1983, the ASN changed the name of the "disposal yard" to "storage yard" in order to obtain an update for its radioactive waste management from the CEA.

Disposal in trenches was examined in preliminary studies on a model in situ, and then authorization to commission was issued in 1969 based on the results. The zone comprised (in fact still comprises) five trenches, numbered T1 to T5, in chronological order of implementation. The useful capacity of each trench varied from one to another, depending mainly on the type of terrain, the available space and the depth of the water table of the chosen location. The trenches, which were trapezoid in shape, were each approximately 5 meters deep, 40 meters long and 10 meters wide. They were hollowed out of the ground, the base was covered solely with a layer of gravel about 10 centimeters thick and they were filled with technological and process waste declared on burial by the nuclear installation of origin to be "low level" (see photo on next page). They were then backfilled and covered with the earth previously excavated. The radioactive waste was at least one meter below the surface and they were covered with a dome-shaped backfill at least one meter thick.

This disposal method was used up to 1974. Cleaning out these legacy trenches requires significant technical resources and presents numerous difficulties. From the point of view of the type of waste put into storage, traceability requirements for the waste stored in these trenches was far less stringent than demanded nowadays by the ASN and there is therefore a great deal of uncertainty surrounding the nature, activity, conditioning and volume of this waste, which might cause problems when it is retrieved. Furthermore, because these trenches were initially designed for disposal, the storage conditions (burying in the ground, conditioning of waste not blocked or embedded) were not designed to allow the waste to be retrieved. Finally, insufficient account was taken of the medium-term environmental impact of disposal in trenches, with provision for just a single containment barrier (the outside of the drums). Over time, this waste contaminated the soil in contact with it, across what the CEA estimates to be approximately 3000 m^3.



View of nuclear installation No. 56 (INB 56) in the 1960s

The ASN requires operators to assume full primary responsibility and establish safe, strict and transparent management of all waste. They will therefore need to take the necessary steps to make waste compatible with the acceptance specifications of existing processing, storage and disposal facilities. At the storage yard, the feasibility study for such an operation was tested on a pilot site in 1995 by retrieving some of the waste buried in trench T2. The waste extracted was triated, classified, processed and reconditioned for storage or disposal in suitable facilities. The feedback from this site allowed suitable safety options for retrieving all waste buried in the trenches to be defined and a waste retrieval authorization was issued in 2003. The site was opened in 2004 in trench T2. This first phase, which

Trenches in the 1970s at the nuclear installation No. 56 (INB 56)

was due to be completed in mid-2006, was suspended when it was discovered that there was a larger volume of waste for retrieval than expected and hence a risk of destabilizing the banks and contractual problems between CEA and its service provider. This phase was resumed in mid-2010 and retrieving all the waste from the trenches will take several more years. The ASN will be monitoring conditions on the site as works slowly progress.

The trenches at BNI 56 illustrate the difficulties inherent in waste retrieval from and decommissioning of facilities not designed with these aspects in mind. New facilities will guarantee better traceability of waste (type and location in the facility) and will have technical arrangements for retrieving waste.

In the case of BNI 56, although the operator initially thought that it had all the data relating to the storage (condition, type of waste etc.) and retrieval project under control, the first sites highlighted uncertainties about origin data which impacted on the time and money aspects of the retrieval operations. The ASN is watching to ensure that this does not impact on the safety levels of storage.

Storage yard: a facility in the retrieval phase

This facility is now used mainly for storage of solid radioactive waste from the operation or decommissioning of nuclear installations inside or outside the Cadarache Centre. As such, it needs to be able to guarantee that it is able to accept, recondition and dispose of the waste packages.

BNI 56 is divided into two separate complexes approximately 1500 meters apart:
– the storage yard itself, comprising hangars, the pools and the trenches;
– the trench zone, comprising the trenches, the TFA hangar and the TFA area.

The waste retrieval phase started at BNI 56 when CEDRA BNI 164 was commissioned.

Waste retrieval management at BNI 56 as a whole is an extensive and complex operation which requires various types of expertise, outsourcing and strict management. In order to satisfy these requirements, the CEA has organized a global project team for this operation, in which each retrieval operation (e.g. trench retrieval project) is piloted by a project manager from the department in charge of Cadarache CEA projects, a batch manager (from the CEA staff at BNI 56) and a site manager (service provider), who ensures that service providers do their work in keeping with site regulations. Although the feedback from inspections of this organization illustrate that it has given new impetus to the projects, it also highlights the CEA's difficulty in fully exercising its responsibility as nuclear operator, given the high level of subcontracting, especially in key positions such as site manager. At present, of the thirty or so agents present in BNI 56, two-thirds are service providers. However, despite everything, the ASN has identified delays in executing contracts and keeping to the timetables defined, due mainly to frequent stoppages on site caused by unforeseen or technical difficulties which required additional studies.

The ASN ensures that the sub-contractors used comply with safety requirements on site and that the operator adequately supervises its service providers, in keeping with its obligations.

Transfer from storage yard to CEDRA: a new generation of storage facilities

The CEDRA facility (conditioning and storage of radioactive waste), which was commissioned in 2006, is designed for the storage of type B solid radioactive waste (IL-LLW mainly from the operation and decommissioning of nuclear installations at the CEA Cadarache Centre).

This waste goes into storage for 50 years in warehouses (LLW) or in cells (ILW), pending deep geological disposal.

CEDRA is to be implemented in four stages:
– stage 1, comprising two LLW package storage buildings (see photo opposite), one ILW package storage building (see photo below), one general resource building and one energy building;
– stage 2, yet to come, comprising one intermediate storage building for waste with no immediate management channel and a processing unit;
– stages 3 and 4, yet to come, comprising gradual extensions to the LLW and ILW buildings.

This installation is designed in part, via stage 1, to replace BNI 56, some of the waste from which is in the process of being transferred to CEDRA. Stage 1 is expected to be saturated for storage of ILW by 2016 and for LLW by 2019. Splitting the design of CEDRA into successive stages gives the installation a

Stacking of packages in a low radiation building

Storage cells in the intermediate radiation building

certain flexibility and means that it will be possible to address new requirements in the future (in terms of capacity and type of waste stored) and to correct or adapt the development of the installation in the medium term.

Although this installation is only recent, the ASN has already identified requirements that were not anticipated at the design stage. This has to do in part with the denuclearization of nuclear sites such as Fontenay-aux-Roses and Grenoble, which need storage capacity at CEDRA for their waste. The properties of the waste from these sites and various constraints during denuclearization result in requests for changes to waste acceptance criteria (e.g. change to limit on dose rate in contact with ILW packages, change to mass of fissile materials acceptable in packages) or changes to parts of the installation in order to temporarily accommodate waste not originally planned for. The initial design of the installation is such that adaptation is still possible.

Operation of the installation has been assigned to an industrial operator. According to the report on inspections to monitor service providers, the organization in place so far allows the CEA to discharge its responsibility as nuclear operator and guarantee that all safety rules and conditions for the installation are complied with by the service providers involved. Nonetheless, the ASN continues to monitor safety at installation level as compliance by and monitoring of service providers is a priority for progress today, as for numerous nuclear installations in the centre.

In addition to action triggered by ASN inspections (governing control) and inspections by the centre's safety team (second-level control), the ASN notes that internal operational measures at the CEA, such as formulating requirements of waste producers or carrying out technical inspections (first-level control), help to constantly improve safety levels (standard of waste management procedures, transparency of safety standards etc.).

Conclusion

In keeping with the law of 28 June 2006 on the sustainable management of radioactive materials and waste, the ASN requires operators to exercise all their responsibility in this sector, by establishing safe, stringent and transparent management of all their waste. Therefore, the ASN ensures that arrangements are made to replace the oldest legacy waste storage facilities with facilities that comply with current safety requirements, in keeping with the approach taken in the National Radioactive Materials and Waste Management Plan (PNGMDR). The retrieval of waste from the Cadarache storage yard and waste management at the CEDRA as described in this article are a specific example of this approach. ■

CEDRA (packaging and storage of radioactive waste) storage facility for radioactive waste (nuclear installation No 164 (INB164)). View of the surface storage shed for drums


STELLA facility in Saclay

SAFETY OF RADIOACTIVE WASTE MANAGEMENT FACILITIES: INSPECTIONS

ASN inspection of waste processing facilities operated by the CEA in the Ile-de-France region

by Brice Baraër, Nuclear Safety Inspector in the Orléans Division, Nuclear Safety Authority (ASN)

Scope of action of Orléans Division

The Orléans Division of the ASN inspects the basic nuclear installations (BNI) in the Centre and Île-de-France regions. It therefore covers the CEA centres in Saclay and Fontenay-aux-Roses. These centres both have solid and liquid radioactive waste processing facilities.

The CEA site in Saclay includes:
– BNI 35, known as the ZGEL (liquid radioactive effluent management zone), which accepts, stores and processes radioactive effluents from the centre by evaporation for the purpose of conditioning in waste packages;
– BNI 72, known as the ZGDS (solid radioactive management zone), which accepts, classifies and conditions solid radioactive waste from the centre.

Similarly, the CEA site in Fontenay-aux-Roses includes BNI 166, known as SUPPORT, which takes charge of the solid and liquid radioactive waste from the centre.

Although basically not included in the CEA research programmes, these installations are necessary to the activities of other, laboratory- or experimental reactor-type installations operated by the CEA and to installations being decommissioned, as they process their radioactive waste.

The Division's main job is to:
– conduct specific and regular inspections of these installations (3-4/year per BNI);
– examine safety dossiers on modifications to these BNI with the technical support of the IRSN;
– ensure that the operator reports important events at the right level, analyses the cause of the event and takes appropriate action to avoid a repeat occurrence.

Context and implications of these installations

Reconciling current processing requirements with legacy waste management

These waste processing installations are old; they were commissioned in the 1950s and 1960s. By default they contain various types of legacy radioactive waste and do not satisfy current criteria and standards for elimination or disposal without processing. The ASN ensures that the safety level of this storage remains acceptable and, if it does not, orders the installations to rectify the situation, construct new storage, look for new waste processing or reconditioning processes or, in some cases, dispose of the legacy waste.

The equipment in these installations is also old and some of it is therefore renovated or replaced in order to ensure that radioactive waste is properly conditioned or classified prior to disposal. This involves changing installations, carrying out works and commissioning new processes or equipment subject to approval by the ASN.

One of the main issues is therefore how to simultaneously manage complex legacy waste disposal projects and renovate lines to process the current flow of waste produced by the CEA centres.

Furthermore, these installations are sometimes contracted out to operators, meaning that the CEA needs to control the services provided in light of the applicable rules.

Safety inspections of waste storage

Managing legacy waste

Another aspect of the life of these installations (and one of the most important) is what is commonly known as the "legacy" of these installations. They are used to store legacy waste in installations which were not designed for that purpose or were designed to what are now out-of-date standards. Consequently, there are two alternatives: to bring the storage up to standard or to transfer the waste to an appropriate installation. However, retrieving, reconditioning and evaluating this waste is no easy matter and the ASN orders the CEA to propose, study and demonstrate the feasibility of solutions, with sufficient risk management in terms of the safety requirements of these operations, and then to implement them.

For example, BNI 35 stores concentrated effluent, organic radioactive legacy waste which has accumulated over several decades. This situation needs to be resolved within the next few years. In fact, the cut-off date set by decree, at the ASN's proposal, is early 2014 at the latest. These often temporary operations are carried out on the basis of specific safety and operating documents, as they are by definition sporadic. These operating documents are submitted to the ASN for approval following examination by the Orléans Division, sometimes after additional information has been requested from the operator. Application of the principles and methods for preparatory operational tests, for emptying the pools, for retrieving the waste and for transferring effluent or waste, is examined during subsequent, sometimes unannounced, inspections. The purpose of these inspections is to check that the procedures used in practice are in keeping with the technical documents examined. The inspectors must also be provided with proof of proper implementation of the work and of controls of these operations carried out by the CEA in keeping with the requirements of the order of 10 August 1984 on the quality of the design, construction and operation of basic nuclear installations. If the Division identifies any discrepancies, it orders corrective action to be taken in follow-up letters sent to the operator and posted online on the ASN website. Requests for justification of certain points requiring clarification are also sent out.

The other storage zone at the Saclay centre (BNI 72) stores numerous different types of radioactive waste (old fuel stored in wells, pools or rock, old high level sources, radium-bearing sources and items collected in France etc.). To summarize, the BNI is in a position to carry out the waste retrieval projects planned. The ASN is in favor of transferring this waste or spent

PETRUS line - using a remote manipulator

fuel to other, more suitable, installations, provided that the retrieval, reconditioning, classification and transportation operations are carried out in total safety, taking account of the uncertainties caused by the fact that the waste or spent fuel in question is so old. The data traceability rules that applied at the time were not as strict as they are now. ASN requirements may therefore result in requests from operators being refused on the grounds that the safety arrangements are not up the standards set, for example in the Basic Safety Rules (RFS). This happened in order to prevent the criticality risk during operations to dispose of spent fuel. In keeping with the principle of in-depth defence imposed by the RFS, which requires that a criticality accident should not result from a single anomaly, the operator therefore had to review its dossier and increase its handling chain, in order ultimately to obtain ASN agreement.

The site at Fontenay-aux-Roses, the cradle of the French civil nuclear industry, also has its share of legacy waste, especially high level organic effluent from research programmes carried out over several decades up to 1995, including into spent fuel processing and the production of transuranium elements. However, the objectives are still the same, namely to know that decontamination and decommissioning operations are under control. One example was the removal of effluent from the PÉTRUS pool B, which required additional inertization to prevent the risk of explosion from the accumulation of hydrogen by radiolysis. Another example was where a dedicated lifting structure was installed above the old CIRCE transportation packaging, where the quality of the static confinement was at stake.

Finally, there may be a shortage of transport packaging approved by the ASN for road transport. Similarly, consignee installations may know of hazards that will disrupt the schedule. Be that as it may, watchword for the ASN is that safety takes priority over schedules or shortages.

The Division is all the more vigilant on this type of site in terms of the arrangements needed because they are, by definition, sporadic projects that generate transitional operating stages in parallel to the ongoing operation of the BNI. This is set out by the ASN in a prior agreement validating the implementation conditions, associated risk analyses and increased control on the ground. Transportation of waste does not escape control by the Division, which carries out unannounced inspections of consignments of packages approved by the ASN, as was the case for the first disposal of high level effluent from pool HA4 at BNI 35.

Verification of installation of new equipment

Installing new equipment

Some installations are now so old that their equipment is obsolete. Other equipment is hard to operate on an industrial scale or is under capacity. Finally, in terms of safety, some processes are out-dated or present specific risks.

For example, the unit for conditioning concentrates in bitumen at BNI 35 was closed in 2003 following negative feedback on the fire risk of this type of installation. This resulted in the CEA constructing a new unit to manufacture cement packages (STELLA). In order to construct this extension to BNI 35, the CEA filed a safety dossier, which was examined by the ASN and evaluated by the IRSN. As a result, the decree authorizing the creation of the BNI in 2004 was revised, after which the Division inspected the site to assess the conformity of the engineering work in light of the safety dossier submitted. Once the unit had been constructed, the equipment underwent acceptance testing on the manufacturer's premises and then in situ for validation purposes. At the same time, the control/command in the old control room was renovated (new interface, specialized study of organizational/human factors to take account of the perception of these highly "technical" tools, renovation of the radioactive effluent acceptance function, with new pumps and valves). The Division carries out controls at all stages, by carrying out at least one dedicated inspection a year of the construction of the future unit (examination of test reports, conditions for controlling services, conformity with safety dossier, modification management etc.). All these aspects are spot-checked to assess the robustness of the system implemented by the operator to obtain an installation that conforms.

Also in Saclay, 36 new ventilated wells for storage of drums of irradiating waste were commissioned at the end of 2009 at BNI 72. Examination of the file will start when a safety file is sent to the ASN, demonstrating that the arrangements put in place for prevention, surveillance and damage limitation are adequate, i.e. that they will ensure that the consequences of an incident are limited and acceptable. Aspects relating to static and dynamic confinement are paramount for this dossier. The Division ensures during inspection that commissioning tests are in keeping with the state of the art, that the expected performance criteria have been satisfied and that the quality assurance arrangements have been implemented satisfactorily.

Finally, an example for the CEA centre in Fontenay-aux-Roses is the current LLW classification line which has been in service since 1991 and has been subject to numerous availability problems. New equipment is currently being installed to provide a tool with sufficient capacity to dispose of waste produced by decommissioning operations at the centre.

The line is located alongside the drum storage zone, so as to limit internal transport and improve efficiency. Similarly, conformity with current standards for the x-ray machine used needs to be verified, as does the quality of the measures taken (gamma spectrometry, neutron counting etc.), so that only approved waste is dispatched. The Division is also studying the

Waste management at the nuclear installation No. 72 (INB72) in Saclay - Storage shed in building 114. Each well is about ten meters deep; the highly radioactive drums are transported here in casks and covered with a concrete plug

analysis made by the operator, in this case of the impact of this modification on its safety documents and carrying out controls.

These examples illustrate how new equipment is installed in these installations in order to meet changing needs. The ASN ensures, at national and local levels, that administrative procedures are complied with and checks during inspections that proper risk management arrangements are in place.

Verification of conditions under which the operation of installations is outsourced

Outsourcing of operation must be controlled

Operation of the radioactive waste processing BNI is frequently outsourced. This sort of arrangement is permissible under French regulations. The ASN pays particular attention to the proper application of binding regulatory requirements governing outsourcing of activities with safety implications, competence and quality guaranties and associated controls. These controls are effected mainly during inspections carried out by the Division. Firstly, they check that due account has been taken of the requirements and constraints linked to the safety and operating documents in the operator's specifications, in order to ensure that the service provider who tenders can submit an informed bid. The terms of selection of the service provider are also examined, even though this is a difficult exercise. In particular, the selection criteria laid down by the operator are examined, in order to ensure that proper account is taken of safety requirements, independently of the financial terms governing the service.

Then, the inspectors look at how these regulatory requirements are included in the contract between the operator and the service provider, so as to ensure that each party's responsibilities are clearly identified and specified. After that, the operator must be able to demonstrate the competence of the agents involved, that interventions carried out are monitored, where necessary with validation by the operator, that important operations carried out for safety purposes are controlled and that audits are carried out in order to evaluate the efficiency of the system to manage the sub-contractor and ensure that service levels are satisfied and detect and deal properly with any shortcomings. All these steps are verified by the Division by spot checking files and on the ground.

Conclusion

Fundamentally, action taken by the Orléans Division of the ASN for waste processing installations does not differ, at first sight, from action taken for other BNI. However, it is predicated on the problems specific to the installations in question and the important implications of radioactive waste processing operations. As such, controls are predicated on the various implications and the specific context in which these centres operate, with numerous projects running in parallel to manage legacy waste and operate the BNI in order to provide support functions to other installations in the centre. ■

SAFETY OF RADIOACTIVE WASTE MANAGEMENT FACILITIES: INSPECTIONS

Former radioactive waste storage sites: the case of the AREVA NC La Hague plant

by Thomas Houdré, head of Caen Division, Nuclear Safety Authority (ASN)

The operation of basic nuclear installations in France in the past generated waste which is stored in various installations which no longer satisfy current safety requirements and in which, therefore, either waste retrieval operations need to be planned or the safety of storage facilities needs to be improved. These old radioactive waste sites include the AREVA installations in La Hague and the CEA research centres (Cadarache, Saclay, Grenoble and Fontenay-aux-Roses), as well as installations belonging to EDF.

The waste stored in these installations is designed to be retrieved, i.e. taken out of storage and conditioned or reconditioned, as applicable. However, these operations are sometimes difficult to carry out and are not always carried out with the degree of priority they deserve by the operators in question, resulting in delays beyond the deadlines announced.

The main challenge over coming years will be to ensure that commitments are honored, especially in terms of deadlines, and to ensure that, pending complete retrieval, the safety level of the installation remains acceptable. Several water tables running beneath some of these old storage sites have already been affected, due mainly to past incidents. Care must be taken to ensure that these installations only have a limited environmental impact.

Storage of legacy waste from AREVA NC in La Hague

Unlike the new UP2 800 and UP3 factories at AREVA NC in La Hague, which condition their waste on line, most of the waste produced during the operation of the first factory (UP2 400) went into storage without final conditioning, in installations which no longer meet current safety standards.

The ASN considers that this storage has serious safety implications, depending on the type of storage. These implications relate mainly to the lack of knowledge as to the exact state of some storage sites and the waste contained in them and the changes they have undergone over time, the old design of the storage sites, which were not designed to resist earthquakes in keeping with current regulations and some of which only have one containment barrier between them and the outside, and the lack of an early warning system for leaks.

The water tables running beneath these installations are checked monthly, from 41 piezometers located on site. This monitoring is supplemented by 12 piezometers located in four surrounding communes. At the very least, overall alpha and beta activity, potassium and tritium are measured during sampling. This sampling, especially in drinking water catchments, has not highlighted any problems with the water. Surface water is also monitored regularly, in application of the provisions of the discharge order. All the measures taken allow legacy pollution on the site from past incidents to be monitored. These measures have not highlighted any new pollution from recent operations or current storage of legacy waste.

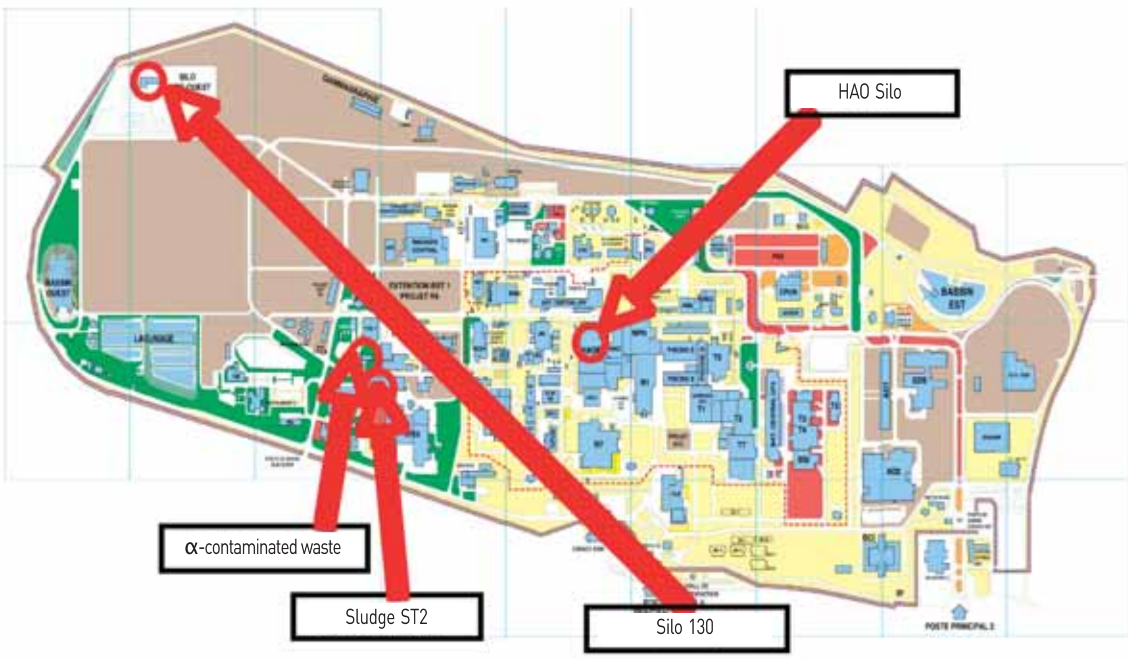
Waste retrieval operations are technically delicate operations that require significant resources. In view of the technical difficulties posed by making modifications to improve the safety of storage facilities, the main concern to the ASN is compliance with the deadlines quoted by AREVA, which often depended on the development of waste retrieval processes that no longer exist. The ASN is mindful of the increased efforts being made by AREVA in this sector to resolve this legacy. In light of the serious delays to most waste retrieval projects over the last few years, the ASN has taken recourse to the binding provisions of the TSN[1] law, in order to set a binding schedule for retrieving this legacy waste. Finally, this situation vindicates the ASN in the obligation it imposes on operators to evaluate their waste production for all projects and to make provision for processing and conditioning of waste as and when it is produced.

Following the examination, in November 2005, of the waste management policy for the La Hague factory by the standing groups of experts for laboratories and factories and for waste, the ASN confirmed the need to start retrieving the sludge stored in silo STE2, the waste in the HAO silo, the waste in the silo in building 130 and the drums of primarily alpha-spectrum waste in building 119 of BNI 38 as soon as possible, as the safety level in these installations was inadequate.

Sludge from processing station for effluent from unit STE2

Between 1966 and 1997, effluent from the AREVA NC in La Hague was processed in installation STE2, by chemical coprecipitation. There is 9,300 m^3 of sludge stored in bulk in silos left over from this process. These silos are made of concrete; some have a steel plate immersed in the concrete, while others have a polyurethane inner coating. The main safety implication of this sludge storage is the risk of dissemination of radioactive materials due to the single confinement barrier (silo walls), the current state of which, due to the passage of time, is unknown. Research over recent years has allowed retrieval and transfer methods to be designed and tested prior to any conditioning. However, the properties of the sludge from unit ST2 are such that it is more difficult to process and condition than the sludge

1. Law no. 2006-686 of 13 June 2006 on transparency and security in the nuclear sector, known as the TSN law.



Locations of the main former waste storage facilities at the AREVA NC site in La Hague

currently produced in the more recent processing station for effluent (STE3), which is conditioned in bitumen and then poured into stainless steel drums in this unit. That is why the ASN issued a decision on 2 September 2008, at the proposal of the standing group of experts, prohibiting bitumen-conditioning of sludge from unit STE2 in unit STE3. The ASN also asked the operator to develop alternative processing and to study the properties of the associated waste package.

Retrieval of this sludge should be completed no later than 31 December 2030.

HAO silo

The HAO silo is made of reinforced concrete lined with stainless steel. It is filled with water up to a height of approximately 9 meters and contains 880 tonnes of bulk waste in the form of hulls and end pieces, fines (dust mainly from shearing), resins and technological waste from the operation of the HAO unit between 1976 and 1997.

The main safety implications of this waste storage are that it is impossible to test the tightness of the casing, the pyrophoricity of certain types of waste (risk of fire if dewatered) and, possibly, the criticality (risk of setting off a fission chain reaction).

Before the waste can be retrieved from the silo, the equipment installed on the silo slab needs to be dismantled. The first stages have already been completed. As there are fines and resins present in the silo, the hulls cannot be compacted as in the UP3 hull compacting unit (ACC). Apart from installing a mechanical retrieval system, a sorting cell also needs to be constructed above the silo, to wash the hulls and end pieces. The fines and resins recuperated will be conditioned in cement in an adjacent cell. The sorting, washing and cementing enclosure is due to be commissioned in mid-2014 and the industrial retrieval service for the silo is due to be commissioned in mid-2015, following a year of active trials. Retrieval of the waste from the HAO silo should be completed by no later than 2022.

Silo 130

This silo, which is located in the northwest corner of the site, consists of a block of reinforced concrete separated into two trenches. The first trench contains 750 tonnes of bulk waste from 1969 to 1984. The second trench contains 1,400 m^3 of effluent. The waste in the first trench mainly comprises structural elements from fuel from the first generation of nuclear power plants (NUGG - natural uranium graphite gas - reactors), plus miscellaneous other waste, mainly contaminated soil and gravel and water used to extinguish the fire in the silo in 1981.

During 2008, the operator amended its plans to retrieve legacy waste, causing implementation delays. The ASN is concerned

ASN waste inspection - Penly nuclear power plant (June 2010)

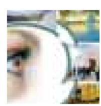
Hulls from fuel assemblies, AREVA NC's ACC workshop in La Hague

about these delays, as this installation does not meet current safety standards. The ASN therefore issued a decision, on 29 June 2010, setting a binding schedule for retrieving the waste from silo 130 (end of 2020 for solid waste and 2022 for effluent and sludge). This decision also orders improvements to arrangements to detect water leaking from the silo and arrangements to contain any such leak.

Alpha-emitting waste from building 119

Building 119 is an accessible, supervised and maintained nuclear building, divided into cells which contain drums of technological waste, primarily alpha-spectrum, the safety level of which is not considered fully satisfactory in terms of seismic and fire risks. The waste stored here is from the operation of the UP2-400, MELOX and ATPu factories.

The operator has implemented a global strategy in order to process the existing drums of alpha waste currently stored in building 119 as a matter of priority. Of the 4,986 drums initially stored in the building, 70% had been retrieved by 1 September 2010. The operator intends to empty building 119 of the drums of alpha waste by the end of 2013. ■



Set up and commissioning of a radioactive waste management facility

by Dimitri Brotte, project manager at the Directorate of Waste Research and Cycle Installations, Nuclear Safety Authority (ASN)

The set up and commissioning of new nuclear facilities are important factors in operators' waste management strategies, both to replace old facilities due for decommissioning and increase storage capacity in order to meet new requirements, for example in connection with the decommissioning of French nuclear installations already under way or planned, or to renew processing installations. The need for new facilities ought to be identified periodically, in order to anticipate the availability of waste management resources for waste already produced or which will be produced in the future. This approach is fully in keeping with the objectives of the PNGMDR, which requires storage or disposal capacity for radioactive waste to be identified (both quantitatively and qualitatively). As such, the role of the authorities, especially the Nuclear Safety Authority, is all the more important in waste management facilities with specific attributes, which require good analysis skills on the part of ASN agents and their technical support.

The set up and commissioning of a basic nuclear installation is subject to authorization under article 19 of the TSN law.

Safety options dossier

It is not obligatory to send the ASN a safety options dossier. However, before any official application for authorization to set up a BNI is made, the operator may ask for the ASN's opinion on all or some of the options it is considering to guarantee the safety of the installation. The ASN then examines the main design features, with assistance from the IRSN and issues an opinion, in which it may stipulate any studies or additional supporting documents needed in order to apply for authorization. This opinion is communicated to the applicant and sent to the ministers responsible for nuclear safety.

For example, the CEA sent the ASN a safety options dossier in connection with plans to construct the DIADEM facility for irradiating or alpha-emitting waste and waste from the decommissioning of PHENIX. Having examined the dossier, the ASN issued its opinion, in which it stated that it had no objection to the continuation of the process to set up the facility, provided that its comments were taken into account and the choice of location was justified.

Examination of application for authorization

The decree of 2 November 2007 on basic nuclear installation specifies in particular that, in order to support an application for authorization sent to the ministers responsible for nuclear safety, the operator must:
– send the ASN a preliminary safety report describing the installation and the operations to be carried out in it, an inventory of its risks of all origins, an analysis of the measures taken to prevent such risks and measures to reduce the probability of accidents and the consequences of them;
– present a dossier for public enquiry, containing various plans of the installation, a danger study and an impact study. This document should also describe the provisions made to facilitate later decommissioning of the installation.

If the operator has already submitted a safety options dossier on which the ASN has issued an opinion, the report should identify the questions already examined by it and the studies and additional justification provided, especially those requested by the ASN in its opinion.

Based on the outcome of the public enquiry and analysis of the preliminary safety report, the ASN will then prepare, if applicable, a draft decree authorizing the installation.

This draft decree sets out the scope and characteristics of the installation and the specific requirements to be satisfied by the operator. This draft is submitted to the ministers responsible for nuclear safety, who pass it on to the operator. The operator then has two months in which to submit observations. Finally, the ministers responsible for nuclear safety finalize the draft decree.

Commissioning of an installation

The commissioning of a basic nuclear installation corresponds to the first implementation of radioactive substances in the installation or the first implementation of a particle beam.

In order to commission the installation, the operator must send the ASN a dossier containing:
– the safety report, together with an updated preliminary safety report and the information that will allow compliance of the installation with the decree authorizing its set up to be evaluated;
– the general operating rules that the operator intends to apply as soon as the installation has been commissioned;
– a study on the management of waste from the installation;
– an internal emergency plan, accompanied by the opinion of the health and safety at work and working conditions committee;
– an updated decommissioning plan for the installation.

The documents received are examined by the standing group of experts in charge of factories (GPU). On completion of exchanges between the members of the GPU and the operator, the operator gives undertakings on points raised during the examination and discussed at the GPU meeting.

The ASN rules on whether or not the safety measures are adequate and may issue additional requests.

At the end of this phase, the ASN holds technical meetings with the operator on the specific requests arising from the examination and their implementation. ASN agents also conduct

Building reservoir - nuclear installation No. 35 (INB 35) - taking samples for analysis using glove box. Nuclear installation No. 35 (INB 35) is a storage and treatment station for radioactive liquid effluents

regular inspections on site and may address various issues (operation, monitoring of service providers, management of discrepancies etc.). This on-site monitoring allows confirmation of compliance with the undertakings given by the operator to the standing group and of the stringency of the tests carried out on site and of the management of associated modifications.

Following these various actions and analysis of the dossier for the application to commission sent in by the operator, which must include a report on the tests carried out to ensure that the installation operates properly, the ASN issues a decision authorizing the installation to be commissioned. The ASN communicates its decision to the operator and sends a copy to the ministers in charge of nuclear safety, the prefect and the local information committee (CLI).

The decision sets a deadline by which the operator must submit a start-up completion dossier to the ASN, containing a summary report on the installation start-up tests, a report on the operating experience gained and updated versions of the documents referred to above.

Specific case of STELLA: commissioning in stages

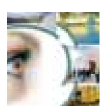
Article 20 of the decree of 2 November 2007 makes provision for commissioning in stages of an installation or part of an installation. This procedure was used during commissioning of the STELLA unit inside the perimeter of BNI 35 (CEA Saclay).

During this modification of the installation, the CEA was authorized to create an extension (STELLA) to BNI 35. This installation was designed to accept radioactive effluent, store it, process it and produce waste packages from cement-conditioning of the effluent concentrate. On completion of these steps, the packages are ready for dispatch to the Aube repository operated by ANDRA. Due to the technical difficulty in manufacturing the waste packages initially planned, the CEA applied to the ASN for authorization to commission the installation in stages, as permitted under the decree of 2 November 2007. This option was justified by the desire to start effluent evaporation pending finalization of the cement-conditioning process allowing the planned waste packages to be manufactured, thereby enabling the operator to continue package rating tests so that it could apply to ANDRA for approval for the nominal package and then start processing the effluent currently stored in the installation.

STELLA is therefore to be commissioned in three stages under successive authorizations from the ASN based on the results presented by the CEA at the end of each stage. Thus, to start with, the CEA will be authorized, based on the justification of the rating of the evaporation process and all the installation support functions (ventilation, control/command etc.), to concentrate LL effluent currently in storage in the BNI 35 tank unit. Then, once it has demonstrated proper rating of the inactive cement-conditioning process (i.e. without any radioactive material in this part of the equipment), the CEA will need to re-apply to the ASN in order to start cement-conditioning and chemical processing. Before this, the CEA will also need to demonstrate that it has approval to manufacture the first packages, which must be barely active. Finally, in order to commission the installation definitively, the CEA will need to obtain approval to manufacture more active packages from ANDRA.

Role of the ASN

Numerous tripartite meetings (ASN/IRSN/CEA) were held during the STELLA commissioning procedure. These technical meetings allowed the conditions for planning the gradual commissioning strategy proposed by the CEA to be defined, compliance by the CEA with the undertakings given to the standing group to be monitored and the results of inactive testing of the unit to be verified, especially the results relating to ventilation.



Control/command room in the nuclear installation No. 35

In addition, alongside evaluation of the commissioning of STELLA, two inspections were carried out during testing of the STELLA unit (September 2008 and April 2009). The ASN noted that there was stringent and in-depth monitoring of tests and of the management of associated modifications.

Particular attention was paid during these inspections to outsourced activities in STELLA. Having examined the draft contracts for outsourced activities, the ASN inspectors noted that significant constraints had been included in terms of keeping the installations in a safe condition and involving staff in safety improvements and that penalties could be imposed on the service provider in connection with these issues.

The regulatory procedure for the set-up and commissioning of new waste management facilities (waste processing/conditioning and storage or disposal facility) is designed to guarantee safe and sustainable management of radioactive waste. New basic nuclear installations to manage radioactive waste will also be commissioned in coming years, such as the DIADEM facility, the AGATE and ICEDA facilities and, in the longer term, repositories for long-lived radioactive waste. ■

SAFETY OF A RADIOACTIVE WASTE MANAGEMENT FACILITIES: EXPERT ASSESSMENT

The Standing Group of Experts on Waste

par Pierre Bérest, chairman of the Standing Group of Experts on Waste (GPD)

The Standing Group of Experts on Waste (GPD) is one of seven groups of experts set up by the ASN. This group was set up to advise the Nuclear Safety Authority (ASN) on safety issues in the radioactive waste sector, including its implications in terms of radiation protection and environmental protection. As such, the GPD helps to develop a safety doctrine.

The GPD comprises around thirty members appointed for four years. The members are selected for their professional or scientific skills, which cover all sectors of interest to the GPD, and some are proposed by government bodies or departments concerned by the problem of waste; the operators concerned are excluded. The members speak on a personal basis and work free of charge. Several members of the GPD, including its vice-chairman, are foreign. The GPD may invite members of other ASN groups of experts to take part in their work (e.g. the Group of Experts on Radiation Protection and, as safety issues relating to deep disposal become increasingly topical, the Group of Experts on Factories).

Apart from internal meetings for information purposes or to organize its activities, the GPD visits facilities, including abroad, and consults with its opposite numbers abroad (especially the German ESK, which it meets with once a year). However, its main purpose is to reply to requests for opinions from the ASN on specific issues.

These issues relate to draft regulations, general nuclear safety problems or dossiers submitted to the ASN by an operator – usually the National Radioactive Waste Management Agency (ANDRA). Examination of these dossiers generally includes a review of the request from the ASN, where necessary a presentation of the operator's position, an analysis of it by the ASN or its technical support, the IRSN, and the formulation of an opinion and possible proposed recommendations. The examination is recorded in minutes of the meeting. The opinion is prepared in the presence of the members of the GPD and the members of the ASN processing the dossier alone and is generally passed by consensus. The opinion reflects the GPD's position on the subject submitted to it and expresses the relevant points of doctrine. This opinion, the letter of referral from the ASN which triggered it and the position taken by the ASN further to the opinion are available to the public on the ASN website.

Some examples are given below.

Safety Guide on Deep Geological Disposal (ex-RfsIII2f)

Without doubt, the most important text the GPD helped to draft is Basic Safety Rule III.2.f, which later became the Safety Guide on Deep Geological Disposal of radioactive waste. The first version of the Rule, which was completed in 1991, was based on the conclusions of a report prepared by a working party chaired by Jean Goguel. The aim of this Rule was to define the objectives to be applied in the study and preliminary works stages for deep geological disposal of radioactive waste. It is unique, compared with other countries, in that it was prepared while this research was still in its early stages - the law on the management of radioactive waste (Bataille law) laying down the bases for a national radioactive waste management strategy having been passed by Parliament on 30 December 1991. The rule sets the protection of human health and of the environment as the basic objective of disposal and proposes that, after a limited period, safety should be guaranteed passively, without any intervention. It sets out the safety principles and the safety-related bases for designing the installation and explains how safe disposal must be demonstrated. Most importantly, it requires the design adopted to ensure that the radiological impact is kept "as low as can reasonably be achieved, in light of the state of the art and economic and social factors" (the principle known internationally as ALARA for waste repositories). Quantified dosage criteria allow the method used to achieve this objective to be evaluated.

The Rule was reviewed by the GPD in June 2007 in light of scientific and technical progress achieved in the interim, the de facto rejection of disposal in saliferous or granite formations, changes in the safety doctrine (especially the inclusion of the notion of safety functions) and the option of reversibility of deep disposal introduced in the law of 28 June 2006. The updated Rule was published by the ASN in February 2008 in the form of the Safety Guide for Disposal of Radioactive Waste in Deep Geological Formations.

Working party on radiation protection

During this review, the members of the Standing Group raised various questions, as mentioned in the letter from the chairman of the GPD in his letter to the ASN containing the GPD's opinion. The ASN decided to set up a working party involving the GPD. These questions related mainly to very long-term safety demonstrations (over a million years) and the relevance of the quantified dosage criteria, given the very long-term nature of the works. In March 2010, the ASN drew its conclusions from the work carried out by this working party, which were presented at an internal meeting of the GPD. As far as the very long timescales are concerned, the ASN emphasized that verification of compliance with quantified criteria was just one of the evaluation factors to be used and that the safety principles and approach applied by the repository designer were basic project evaluation factors. The ASN did not adopt the "cut-off" option (i.e. to disregard the results of dosage calculations beyond one million years) adopted by other countries. For dosage criteria, the ASN proposed close monitoring of international debate and asked for the opinion of the ICRP (International Commission on Radiological Protection) on the radiation protection rules applicable to disposal. It emphasized that, far from confining itself to verification of compliance with

Public information centre at the Manche repository

quantified dosage criteria, the works designer, the evaluators and the ASN needed to pay very close attention to compliance with the ALARA principle in the guide.

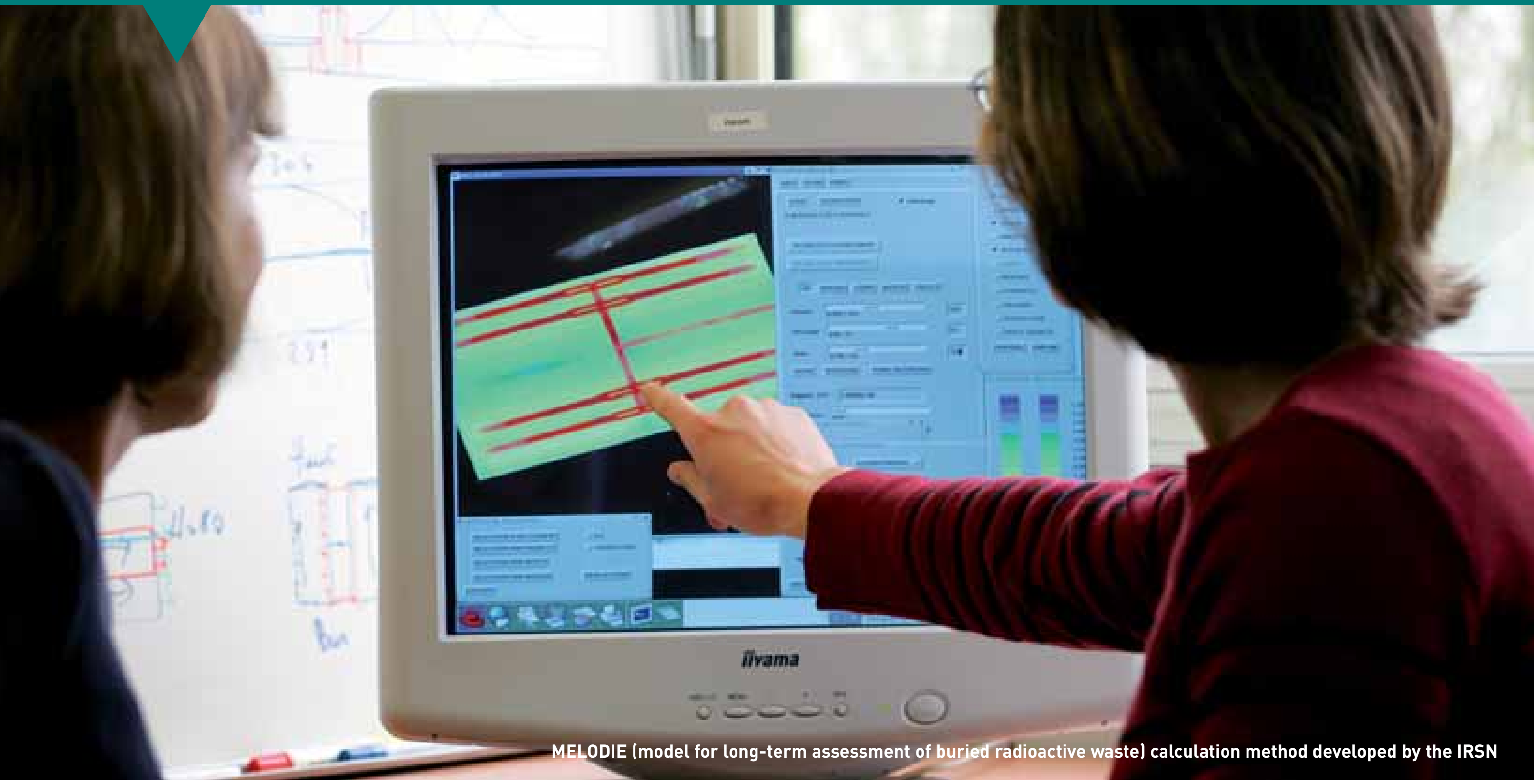
Final safety report on the La Manche repository

The GPD also examines dossiers on disposal projects at regular intervals (Dossiers 2005 and 2009 Clay, on HL-LLW and IL-LLW disposal projects in Meuse and Haute-Marne) and on specific existing repositories (LL-SLW and VAL-SLW repositories in La Manche and Aube). The last such dossier which the GPD examined was for the La Manche repository (CSM). This centre, which was set up by the CEA and authorized by decree of 19 June 1969, has been managed since 1979 by the National Radioactive Waste Management Agency (ANDRA), at that time a department of the CEA and, since 1991, a public industrial and commercial institution. It was also at that time that the central department for the safety of nuclear installations, which qualifies as the predecessor to the ASN on several counts, and laid down package acceptance criteria. In 1984 and 1986, basic safety rules were issued for this type of disposal. In 1996, the Government set up a committee, chaired by Michel Turpin, to evaluate the situation at the CSM and issue an opinion on its environmental impact. This committee validated the inventory carried out by ANDRA, having identified hot radionuclide zones and large quantities of lead in the repository. It highlighted contamination of the water table, mainly with tritium, and concluded that the site was not "releasable" for 300 years. It recommended implementing a very long-term confinement barrier and setting up a monitoring committee specific to this centre. The centre was closed in 1994. Since the end of 1995, the repository has been protected from ingress of rainwater by a watertight cover between 4 and 10 meters thick which incorporates a geomembrane. A decree dated 10 January 2003 ordered the centre to be placed under surveillance for approximately 300 years.

On 8 December 2009, at the request of the chairman of the ASN, the GPD examined the final safety report prepared by ANDRA, on the basis of the analysis carried out by the IRSN, together with a report on the need for a more permanent cover and arrangements to preserve and transmit the centre's memory, given its specific attributes. The GPD concluded that ANDRA's monitoring arrangements were providing a full understanding of the behavior of the works and that they were in keeping overall with ANDRA's forecasts, with the exception of a local increase in a number of piezometers of the radioactive concentration of tritium. It recommended that the causes be investigated and, on a more general note, that surveillance continue. The GPD approved the gradual implementation, over the next fifty years, of a final cover for all waste with a much gentler gradient than was currently the case. It underlined the importance of robustly designed water capture and drainage arrangements which would guarantee the permanence of the works beyond the surveillance stage. The GPD approved the objectives of the two memory transmission methods proposed by ANDRA (the "detailed memory" to preserve information required by the operator throughout the surveillance phase and the "summary memory" to provide future generations with information that will allow them to evaluate the risks associated with disposal in the post-surveillance phase). However, it recommended that information search exercises be carried out by outside experts to test these "memory" arrangements).

Conclusion

These few examples illustrate the field of activity and working methods of the GPD. It is clear from its twenty years in operation that it has made a useful contribution in helping the ASN and its predecessors. The GPD continues to examine ways, in liaison with the ASN, of better tailoring its working methods to its objectives and this resulted in a restructuring of the standing groups of experts in 2008-2009. It is keen to give its members the opportunity to improve their knowledge and to access dossiers well upstream of their examination. ■



MELODIE (model for long-term assessment of buried radioactive waste) calculation method developed by the IRSN

SAFETY OF A RADIOACTIVE WASTE MANAGEMENT FACILITIES: EXPERT ASSESSMENT

Radioactive waste management: the contribution of expert assessments to the implementation of safe management channels

by Anne-Cécile Jouve, assistant and François Besnus, head of Irradiator, Accelerator and Waste Management Facility Safety Evaluation Service, Radiation Protection and Nuclear Safety Institute (IRSN)

Radioactive waste management is vital for all industrial projects involving the use of radioactive materials. The law of 28 June 2006 on the sustainable management of radioactive materials and waste and the National Radioactive Materials and Waste Management Plan (PNGMDR) give France a regulatory framework for implementing management channels for all radioactive waste from the nuclear industry. Within this framework, the aim of expert assessments by the IRSN is to evaluate the safety level of the various management channels implemented or planned and the robustness of the management strategies deployed. By identifying the priorities, these expert assessments help to constantly improve the safety of waste management channels. In order to be able to give a substantiated opinion on the relevance of these management channels, the Institute needs to acquire, collate and summarize knowledge in three particular areas:
– the safety of existing installations and the radioactive waste management strategy of nuclear operators;
– the quality of the radioactive waste packages produced;
– the safety of existing or planned repositories.

These three points are described in detail below.

Specific inspection of the installation and the horizontal waste management safety vision

Having carried out expert assessments of the safety and radiation protection of all basic nuclear installations (BNI), the IRSN has in-depth knowledge of these installations, especially in the types and properties of waste produced and the associated treatment processes. This knowledge underpins expert assessments by the IRSN on the relevance of the measures taken by each BNI in the waste management chain, both "simple waste producers" (research laboratory, reactor, factory) or dedicated radioactive waste processing centres. In the first case, we evaluate the operator's control of the inventory of radioactive and chemical waste produced and the potential disposal channels for this waste. In the second case, we evaluate the installation's processing and storage capacity and the suitability of the processing products (evaporated effluent, waste packages etc.) for subsequent steps (product conditioning and disposal). For example, the recent IRSN evaluation prior to the commissioning of the AGATE effluent processing facility at the CEA Cadarache centre highlighted uncertainties in terms of processing concentrates produced by this new BNI in an old facility in need of renovation.

Analysis of horizontal waste management dossiers from various operators allows us to examine the robustness and coherence of an operator's overall strategy and the efforts being made to optimize management of the waste produced from the safety point of view. The IRSN evaluates the credibility of the management channels chosen in terms of deployment timetable (hazards for new constructions, hypotheses in terms of retrieval of legacy waste or the permanence of the facilities, availability of the necessary transport packaging etc.) and compliance with conditioned and non-conditioned waste acceptance criteria in the various installations of the chosen management channels. These evaluations also give us an opportunity to identify difficult points and ways to improve them. The expert assessments carried out by the IRSN therefore aim to identify hazards in chosen strategies and to alert the ASN of the need for operators to propose alternative solutions which take account of such hazards.

Waste packages: the core element of the management arrangement

Controlling the risks linked to radioactive waste depends on a set of "active" or "passive" arrangements designed to guarantee the safety of the various waste transport, storage and disposal operations. Of these arrangements, conditioning waste in the form of packages comprises a set of operations designed to confine the waste "as closely as possible", mainly in order to reduce the design and operating constraints on disposal facilities. The choice to implement conditioning operations must be made with the objective of making it easier to attain a high level of safety during the successive steps leading to final disposal of the waste.

This principle is all the more important as certain waste does not currently have a final disposal channel and the producers do not therefore necessarily know precisely what set of steps might follow before the waste is eliminated. In fact, depending on the time needed to create and commission a new repository, the packages produced may be transported and stored in various facilities in succession (producer's site, centralized storage etc.). Given these uncertainties and in order to mitigate the lack of precisely defined conditions of acceptance of the packages in the future repository, waste conditioning needs to be designed to produce an "intrinsically safe" package which will impose as few constraints as possible on the design and operation of the facility which accepts it. Packages therefore need to be designed to form an efficient confinement barrier under various environmental and operating conditions.

An IRSN engineer takes part in the resistance testing in an accident situation of a package design intended for transporting bituminized packages at the test station of TN International

As far as storage is concerned, the best type of package, in terms of these objectives, has been established from feedback. The main aim, in order to comply with the safety requirements of these facilities, is to ensure that the package has the minimum possible chemical reactivity, low flammability, limited radiolysis gases, little potential for disseminating the radioactivity contained in it, the mechanical properties needed to preserve confinement in various situations (stacking, falling loads) and properties that allow criticality risks to be controlled. These properties are equally favorable in terms of the safety of repositories, both during operation and after closure, with the additional requirement, depending on the level of risk inherent in the package, of having to limit release over much longer periods of time and under different environmental conditions. This mainly implies focusing on the resistance to corrosion of the package envelope, limiting release in the event of ingress of water using a matrix to incorporate the waste and knowing the impact of chemical change in the package on the mobility of the radionuclides released.

It was basically by referring to these favorable properties that an expert assessment was made of the specifications for the production of new waste packages.

Towards new conditioning processes?

The objectives referred to above, in terms of producing an "intrinsically safe" package, have been achieved overall for LL-SLW and IL-SLW destined for disposal at the ANDRA surface repositories. The experience acquired and the expert assessments made demonstrate that, in fact, cemented waste packages or packages processed by incineration or fusion (processes used at the CENTRACO facility operated by SOCODEI) have favorable properties in terms of acting as a first confinement barrier. At the other end of the chain, vitrification is also a favorable technique in terms of the overall safety of the waste management channels, offering a processing solution for high level effluent from spent fuel processing and producing packages with favorable properties for future disposal.

On the other hand, certain IL-LLW, such as organic waste, raise questions and compacting is generally used in order to reduce the volume and optimize storage. Expert assessments by the IRSN have demonstrated that this process does not give the packages produced the most favorable properties for deep geological disposal, due to the lack of matrix. This does not mean – at least not necessarily – that it is impossible to dispose of them, as the geological barrier may possess properties that mitigate the poor confinement properties of these packages. Be that as it may, the development of new (especially thermal) processes which would improve the confinement properties of IL-LLW packages needs to be examined. Even though the decision to implement them depends on numerous factors (mainly the number of packages needed, the risks induced by the process itself) is a question that needs to be addressed in order to assess the contribution of such processes to the overall safety of management methods.

Repositories: the cornerstone of waste management channels

The creation of the Aube repository (CSA), following the closure of the La Manche repository (CSM), provided a technical solution for the final disposal of most LL-SLW generated by operating current installations. On the other hand, the recent suspension of the procedure to find a repository site for LL-LLW may cause EDF to further postpone the decommissioning of first generation reactors, with safety implications that need to be assessed.

The availability of a repository in which to dispose of the various categories of waste produced is therefore a fundamental factor in optimizing the safety of the management channels for this waste. In this respect, the creation of a deep geological repository for HL-LLW or IL-LLW, for which ANDRA will need to file an application by 2015 (according to the deadlines set in the law of 28 June 2006) is a major step in the management of the most harmful type of waste. However, the expert assessment of such a facility is very different in nature. Due to the shortage of feedback available, the American WIPP (Waste Isolation Pilot Plant) is in fact the only repository in the world for waste containing transuranium (similar to IL-LLW), but it is in a geological formation (salt) which is very different from the hard clay formation studied for the French repository and a great deal of research was needed, mainly by ANDRA, to design the repository, and by the IRSN, to be able to give a relevant opinion on the key safety factors of such a repository. Also, the mining aspect of the facility and its gradual development need to be specifically addressed.

R&D and expert assessment

In terms of research and development work, very significant progress has been made over the last twenty years, especially in terms of knowledge about clay environments. The expert assessments carried out in 2005, when the 1991 law on radioactive waste expired, to be replaced by the law of 28 June 2006, concluded that a repository in the clay formation, studied in the underground laboratory in Bure, was feasible, especially as the overall properties of this environment were favorable for the works designed by ANDRA. In order to reach this conclusion, the IRSN had to conduct research, independently of the research carried out by ANDRA, into the key safety factors of such a repository. In particular, the results obtained by the Institute at its experimental station in a clay formation in Tournemire (Aveyron) showed important similarities with those obtained at Bure, thereby enabling it to verify that the protocols used by ANDRA allowed the confinement properties of the rock to be qualified, and also led ANDRA to refine its site reconnaissance strategy (mainly to confirm the interpretations of the seismic reconnaissance campaigns carried out on the surface).

The IRSN therefore obtained knowledge and experimentation and modeling resources which directly added to its expertise and enabled it to deliver its opinion in due time. Although important progress has been made, research efforts did not stop there, either for the designer or for the public expert. In this sense, research may be expected to refocus on the rating designs for works, especially of sealing works, for which in situ demonstrators will need to be implemented. The IRSN is planning to develop its research programme here, so that it is in a position to evaluate the results of the rating tests carried out as ANDRA works proceed.

Drilling boreholes in a gallery at the Tournemire test station where the IRSN is carrying out its own research on deep geological disposal of waste.

Adapting expert assessments to each individual installation

Just as research needs to evolve, expert assessments need to adapt to each individual installation. In addition to the long-term safety of repositories, which has been the focus of efforts by the scientific and technical community, the practices implemented in other basic nuclear installations will need to be adapted in order to guarantee the operational safety of the repository. This applies in particular to dynamic confinement arrangements in the various parts of the repository and to fire-fighting arrangements, which need to be adapted to take account of the fact that the facility is underground. Elsewhere, the quasi-permanent coexistence of a construction zone and an operational nuclear zone, which is a rare occurrence, may harbor risks to which particular attention must be given. As a first step, packages and their enclosures (double drums, transfer box etc.) will need enhanced confinement levels to take account of the various situations (normal or one-off) that may arise. The operational safety of the repository needs to be based on a combination of best practices in mining and in the nuclear sector.

Finally, the period over which the repository will be operated is an important factor in light of the objective of constantly improving the safety of these facilities. This period, which is measured in centuries, will need to be used to make the most of the experience acquired over time so that, where necessary, the initial designs can be improved on the basis of the results of in situ demonstrators and the feedback from the first works. Nonetheless, adequate evidence of the safety of the repository as a whole is needed in order to rule on the creation of the facility by the statutory deadline. Thus, this safety demonstration will need to be based on a "reference" design which can evolve over time, in light of the experience acquired and in keeping with the properties of works and equipment constructed at an earlier date (e.g. the wells, shafts and ventilation). This constitutes the main challenge in terms of expert assessments by the IRSN, which need to shed the necessary light on the fundamental demonstrations that need to be provided at the various stages of construction, as the various parts of the facility are installed.

Conclusion

Expert assessments on radioactive waste management channels need to be based on multiple levels of knowledge, gained from examining the safety of installations and from horizontal examinations of waste management by various nuclear operators, and research results. With its knowledge of all basic nuclear installations in France and its ability to conduct the research needed to substantiate its expert assessments, the IRSN contributes towards the overall objective of improving the safety of waste management methods - by identifying best practices and possible bottlenecks in those channels - the robustness of which is what guarantees long-term control of the safe management of radioactive waste. ■

Waste management outside basic nuclear installations

1 Main rules regarding the management of solid waste and liquid effluent contaminated during use at nuclear medicine departments

by Élodie Boudouin, project manager at the Directorate of Ionising Radiation and Health, Nuclear Safety Authority (ASN)

General contaminated waste and effluent management arrangements for the nuclear activities referred to in Article R. 1333-12 of the Public Health Code[1] are set out in the order of 23 July 2008 on homologation of ASN decision no. 2008-DC-0095.

This decision, which adopts some of the recommendations set out in circular DGS/DHOS of 9 July 2001 on the management of effluent and healthcare waste contaminated by radionuclides, sets out the technical rules governing waste management; these rules became binding on the date of publication of the decision (2 August 2008), which also set application deadlines (Article 26).

This article describes the main requirements governing contaminated effluent and healthcare waste in healthcare establishments and, more importantly, in nuclear medicine departments which use radionuclides for diagnosis (*in vivo*[2], *in vitro*[3]) or treatment and sets out the main management rules, with a distinction made between contaminated solid waste and contaminated liquid effluent produced by these nuclear medicine departments.

Contaminated solid waste management: double management depending on the period of decay of radionuclides used

Waste contaminated with radionuclides presents a risk of exposure and contamination which needs to be controlled in order to protect:
– workers (laboratory staff, care staff, maintenance engineers, agents in charge of management of waste for disposal, i.e. who retrieve, store, transport, process and eliminate waste);
– the public, patients and their friends and family;
– the environment.

Also, it must be disposed of in authorized channels and under conditions that ensure that risks of exposure to and contamination by radiation are controlled.

In practice, a distinction needs to be made between two cases:
– waste containing radionuclides which decay in less than 100 days (very short-lived waste);

1. This applies to all nuclear activities authorized or declared, other than those carried out in the following installations:
- basic nuclear installations;
- nuclear defence installations;
- installations subject to authorization under Article 83 of the Mining Code.
2. Diagnostic *in vivo*: study of the metabolism of an organ using a tracer (radiopharmaceutical) administered to the patient.
3. Diagnostic *in vitro:* use of radionuclides without administration to the patient to dose certain contents of body fluids (blood, hormones, medication, tumour markers).

Storage facility for contaminated solid waste from a nuclear medicine department

Radionuclide used	Period of decay (T)
F-18	1.83 h
Tc-99m	6 h
I-123	13 h
In-111	67 h
Tl-201	73 h
Ga-67	78 h
I-131	8 days
I-125	59.9 days

– waste containing radionuclides which decay after 100 days (short-lived waste).

Solid waste containing radionuclides which decay in less than 100 days

Most radionuclides used for in vivo applications decay in less than 100 days (e.g. technetium 99m, thallium 201, iodine 123, iodine 131, fluorine 18 etc.).

Technetium 99m (low radio toxicity, decays in 6 hours) is the main radioactive element used for *in vivo* diagnostic.

Solid contaminated waste is therefore sorted by period of delay and level of radioactivity, conditioned as far upstream as possible in special bins and stored in a storage facility (see photo on previous page) pending disposal following decay.

In addition, in order to verify that waste destined for non-radioactive waste management channels is not contaminated, detection systems such as marking or a detection gate must be implemented at the exit of hospitals with a nuclear medicine department.

Solid waste containing radionuclides which decay after 100 days

In biomedical laboratories (diagnostic or research *in vitro*) which may or may not be integrated into nuclear medicine departments, most of the radionuclides used decay after 100 days (e.g. cobalt 57, tritium and carbon 14).

Waste from use of these radionuclides is sent to ANDRA (National Radioactive Waste Management Agency).

Management of contaminated liquid effluent[4]: technical and financial difficulties to be taken into account

Contaminated liquid effluent from nuclear medicine departments originates from various sources:
– sinks in laboratories used for preparation and manipulation or injection rooms ('active' sinks);
– sanitary facilities in the nuclear medicine unit (for use by injected patients);
– sanitary facilities in specially protected rooms (radiation therapy rooms[5]).

Liquid effluent containing radionuclides which decay in less than 100 days

Contaminated liquid effluent from the use of radionuclides which decay in less than 100 days may be discharged into the environment under the same conditions as non-radioactive effluent, but only if it is managed by radioactive decay. In order to guarantee radioactive decay, effluent is channeled either to a system of vats (see photo below) or storage containers or to an arrangement that prevents direct discharge into the sewage system.

In practice, some hospitals with a nuclear medicine department encounter technical and financial difficulties in implementing such arrangements, given the large volumes of liquid effluent that require management. The main difficulties are caused by the fact that existing facilities are difficult to modify at a reasonable cost.

Liquid effluent containing radionuclides which decay after 100 days

It is prohibited in principle to discharge effluent containing radionuclides which decay after 100 days. However, the ASN may grant permission to discharge effluent containing radionuclides that decay after 100 days into the sewage system, subject to certain conditions (technical and economic study to justify the efficiency of the arrangements implemented, impact study on local residents, the environment and workers possibly at risk of exposure etc.).
It is also important to remember that:
– any discharge of non-domestic waste water into the sewage system must be authorized in advance by the water board. This

Radionuclide used	Period of decay (T)
Co-57	271.8 days
H-3	12.3 years
C-14	5,730 years

4. Gazeous effluent is not dealt with in this section.
5. Treatment of certain types of cancer (e.g. thyroid) by administration of a radioactive product (iodine 131) requires hospitalization in a protected room. During hospitalization, the radioactive product is gradually eliminated naturally (in the urine, faeces etc.).

effluent is subject to authorization specifying the properties that the effluent must have in order to be discharged and the monitoring conditions of such discharges. This authorization is issued in application of Article L. 1331-10 of the Public Health Code;

– voluntary dilution of contaminated liquid effluent prior to discharge is strictly prohibited.

Contaminated Waste and Effluent Management Plan: reference document

All management methods for contaminated waste and effluent from nuclear medicine services and from establishments in general are described in a master document, the Contaminated Waste and Effluent Management Plan.

This plan, which is established either for an individual nuclear medicine department or for an individual hospital, defines the sorting, conditioning, storage, control and disposal conditions for waste and effluent produced by the nuclear medicine department or by the hospital, where several units produce contaminated waste or effluent and use joint resources.

This plan forms part of the application for authorization to hold and use radionuclides in nuclear medicine.

Storage tanks for contaminated liquid effluents from a nuclear medicine department

Short- and medium-term outlook: from publication of a guide for professionals to evaluation of the application of the order of 23 July 2008

The ASN is currently preparing a guide setting out the methods for applying decision no. 2008-DC-0095. This document, which is expected to be ready in early 2011, is intended as a guide for professionals involved in the management of contaminated waste and effluents. The ASN also plans to evaluate the application of the ordinance of 23 July 2008. Although the working method has yet to be decided, the ASN plans to set up a working party involving all stakeholders to inventory the situation and propose topics for discussion in order to address any difficulties on the ground. ■

All the regulations in the ordinance of 23 July 2008 on homologation of ASN decision no. 2008-DC-0095 are available at www.asn.fr.

2

Feedback regarding leaks in pipe work

by Céline Guerville, project manager at the Marseille Division, and **Élodie Boudouin,** project manager at the Directorate of Ionizing Radiation and Health, Nuclear Safety Authority (ASN)

Professionals work together with the ASN to provide feedback regarding leaks of contaminated effluent from nuclear medicine in pipe work.

The Nuclear Medicine Department of the Val d'Aurelle Paul Lamarque Regional Cancer Hospital (CRCL) in Montpellier and the Hospital Group (GH) La Pitié Salpêtrière (Paris), in collaboration with the Marseille Division of the ASN, published a thematic poster for the French Radiation Protection Society awareness days in June 2009. This poster is based on lessons learned from leaks in pipe work used to carry contaminated liquid effluent from hospital rooms used for patients treated with iodine 131[1] in both these hospitals.

Similar events which occurred recently and were declared to the ASN resulted in recommendations being sent to all nuclear medicine departments, which relayed the work carried out by CRLC Val d'Aurelle, the GH La Pitié Salpêtrière and the Marseille Division.

Contaminated effluent from nuclear medicine departments is, in fact, stored in decay vats before being discharged into the sewage system. These vats are generally located outside the hospital departments, in the hospital's technical installations. However, the pipe work between the points of discharge (sanitary rooms in protected hospital rooms, for example) and the vats may be routed through various premises (hospital departments, corridors, offices etc.). A leak in this pipe work may therefore impact on the public, on workers or on the environment.

Following the leaks declared to the ASN[2] as significant radio protection events, a working party was set up between the hospitals in question and the ASN in order to learn lessons from the malfunctions identified, avoid a repeat occurrence and ensure that the professionals concerned take full advantage of feedback and best practices.

The investigations carried out by this working party highlighted the following shortcomings: the pipe work containing or carrying contaminated liquid effluent ("radioactive pipe work") has not been mapped and the radioactive pipe work is not identified in situ by adequate regulatory signs[3];
– the state of the system in the hospital and, in particular, of the radioactive pipe work, was not being monitored;
– where there was an alarm (e.g. for the decay vats), it was not tested or relayed to premises which are permanently staffed; leaks may occur outside the working hours of the nuclear medicine department and not be quickly detected;
– the pipe work is not included in risk analyses;
– the methods of intervention in the event of a leak in radioactive pipe work have not been defined or are not known to the persons required to intervene (security company, plumbing company etc.).

Thematic poster on good practices: management of a leak in contaminated liquid effluent pipes

The analysis carried out following these declarations also highlighted a number of regulatory obligations that were not being discharged, especially:
– the obligation to identify visible pipes containing or carrying dangerous substances or preparations (see photo below);
– the obligation[4] to train workers who may be required to intervene in monitored or controlled zones in radio protection, by apprising them of the general rules of prevention and radio protection, the specific risks and procedures applicable to their job and the code of conduct in the event of a malfunction;
– the obligation[5] to establish a prevention plan describing preventative measures, for the attention of workers from outside firms who intervene to carry out or are involved in carrying out repairs in the hospital.

In order to capitalize on this feedback, radioactive leak management aids have been issued, for use both in the emergency phase and in preparing and monitoring repairs to pipe work (checklist for use where a radioactive leak is detected, protocol for work on contaminated effluent pipe work).

These summary operational tools safeguard compliance with current radiation protection regulations. ■

Pipes carrying contaminated liquid effluents

1. Treatment of certain types of cancer (e.g. thyroid) by administration of a radioactive product (iodine 131) requires hospitalization in a protected room. During hospitalization, the radioactive product is gradually eliminated naturally (in the urine, faeces etc.).
2. The declaration of significant radiation protection events, which is mandatory under Articles L. 1333-2, R. 1333-109 and R. 1333-110 of the Public Health Code and Article R. 4451-99 of the Labour Code helps to improve radiation protection. The declaration form is available on the ASN website (www.asn.fr).
3. In accordance with Article R. 231-51 of the Labour Code (recast in Articles R. 4411-2 to R. 4411-6), adopted in the ordinance of 4 November 1993 on safety signs and health at work, and Article 20 of the ordinance of 23 July 2008 on homologation of ASN decision no. 2008-DC-0095 of 29 January 2008 laying down the technical rules governing the disposal of contaminated waste and effluent.
4. In accordance with Article R. 4451-47 of the Labour Code.
5. In accordance with the provisions of Title 1 ("works carried out in an establishment by an outside firm") of Book V ("prevention of risks linked to certain activities or operations") of the Labour Code.

3

An example of the treatment protocol in the case of a patient who has received a radioactive product

by Nathaniel Izambard, Radio Protection Engineer, Directorate of Biomedical Equipment, CHU, Rouen University Hospital

The radiation protection cell at Rouen University Hospital participated at the end of 2009 in the debate initiated by the hospital's Protocols Committee (Directorate of Healthcare) on the management of all hospital healthcare waste (including radioactive waste), in order to comply with the requirements laid down by the Health Authority.

These new arrangements had to integrate the management methods for radioactive waste from the radio analysis laboratory at the Hospital's Bioclinical Institute in accordance with the ordinance of 23 July 2008[1].

In order to do so, a survey was carried out of the University Hospital departments involved, with the collaboration of the Nuclear Medicine Department of the neighboring Henri-Becquerel Regional Cancer Centre (CRLCC), which is the main producer of radioactive waste.

The results of the survey highlighted the fact that there was a lack of information exchange between the various operators that might result in erroneous channeling of radioactive waste and insufficient knowledge on the part of the Hospital's healthcare services of the radiation protection rules applicable to radioactive waste management.

All these steps were set out in the new internal protocol entitled "Treatment protocol for patients who have received a radioactive product".

Organizing requests for external examination

The emphasis was placed on the traceability of the various documents completed by the departments in question which accompany patients during their stay.

A copy of the "request for external examination" form, stating the nature of the examination prescribed (e.g. bone scan), must accompany the patient on admission to the healthcare department by the University Hospital ambulance department. This document must be handed over by the ambulance officer to the nuclear medicine department. The ambulance officer must send the liaison document provided by the CHB (for diagnostic and therapeutic examinations) to the healthcare department, when the patient is re-hospitalized after administration of the radioactive product. This document contains all the radiological information required to identify the packaging required by the University Hospital for this type of waste and the radiation protection precautions which must be taken by healthcare services and patients and their family and friends.

Identifying radioactivity in the healthcare service

The healthcare services must identify packaging containing radioactive waste (diapers, boxes of needles, filter infusers, compresses, gloves, cotton wool, smear tubes etc.) and biological samples to be sent to the laboratory clearly and legibly, based on the radiological information available on the liaison document provided by the CHB (type, activity and period of decay of radionuclide, examination carried out, date of administration) and the additional information available in the protocol.

Disposing of waste

Radioactive containers must be closed after 48 hours and then sent to the various storage sites belonging to Rouen University Hospital (Charles Nicolle Hospital, Bois Guillaume and Saint Julien). The storage site for radioactive waste and effluent from the laboratories in the IBC accepts radioactive packages from Charles Nicolle Hospital. Two rooms have been specially equipped on the Bois Guillaume and Saint Julien sites.

Pre-disposal controls of this waste are carried out in order to ensure that the decay period[2] set by the hospital (90 days) is complied with. ■

1. Decree of 23 July 2008 on homologation of ASN decision no. 2008-DC-0095 of 29 January 2008 laying down the technical rules governing the disposal of contaminated effluent and waste.
2. NB: waste which decays in less than 100 days cannot be sent to a non-radioactive waste management channel within 10 times the period of delay of the radionuclide. This period may be curtailed subject to justification in the management plan (cf. Article 15 of ASN decision no. 2008-DC-0095).

4

Managing medical treatment waste and effluents: the point of view of a nuclear medicine practitioner[1]

Interview with Professor Gilles Karcher, head of the Nuclear Medicine department at the Hôpital d'adultes de Brabois – CHU Nancy (Meurthe-et-Moselle)[2]

***Contrôle:* Professor Karcher, your Nuclear Medicine department is one of the biggest in France, particularly for PET-CT imaging. Your work, using isotopes like technetium and iodine-131, produces radioactive waste; can you tell us how this is managed by the hospital?**

Let us remember to begin with that where the nuclear medicine group is concerned, all the products that we use are short-lived isotopes which have no impact or cumulative effect on the environment. The most hazardous isotope that we use in metabolic radiotherapy is iodine-131[3], for which we have specialized equipment: so-called "hot rooms" lined with lead to accommodate patients for the two to five days that their treatment usually lasts, with the effluents collected in special decay tanks, a dedicated storage zone for solid waste for the three months of radioactive decay, etc. We also apply very strict procedures to all our activities, to protect our patients and our staff against radiation. So we are particularly aware of radiation protection issues and, I think, quite exemplary in terms of the initial training of our medical and paramedical staff.

When it comes to managing the waste, we handle the whole decay process in-house. In particular, we keep surgical waste and soiled bedding for 3 months. To limit the risk of infection from the lengthy retention of this waste, we have installed a cold store to restrict any "seepage". This cold store is not mandatory or required by law, but it seemed essential to us because we are not allowed either to keep medical waste or to discard radioactive waste. So we arrived at a sort of compromise, which I am not even sure is completely in line with the regulations. This cold store for our bins represented an investment of several tens of thousands of euros.

After three months of decay, we perform an initial check on our waste before taking it out of the storage zone, and then we do a second check on the loading platform for waste from the CHU. Finally, it is checked for a third time before going into the incinerator.

The cycle in our nuclear medicine department is thus extremely controlled. It is more complex, if not impossible, in the other departments. Some of the patients that we receive are referred to us by departments where they are receiving other treatments, and only need to be examined in our department. When they return to their original department, they use the normal toilets and the materials are also put into the usual bins for contaminated waste. The classic example would be children or incontinent older patients. So, apart from having our own equipment, the CHU tags all the waste produced (domestic, medical, etc.), some of which may not have been identified as potentially radioactive. Thanks to this dual control, we have a very low incident rate.

Remember that 80% of the people examined are outpatients. When these patients return home, they use their own toilets and their own bins. In the case of domestic waste, there are no regulations because they would be impossible to apply. So there is no checking, because no checking is feasible. Given the nature of the radioactivity in question, the risks are trivial in any case, and any regulation would be futile.

When it comes to waste management, the question is how to determine the amount that can be discarded without any negative effect on the public or the environment from incinerating the waste or discharging waste water into sewers and rivers.

To illustrate my point and to understand the orders of magnitude that we are faced with, our work consists in injecting patients with doses of radioactivity in the order of 500 megabecquerels[4] intravenously, or 100 million becquerels (Bq) per litre of blood. At the same time, the regulations set the tolerance threshold in the waste water that we discharge at 10 becquerels per litre of technetium, which is less than the natural radioactivity of sea water[5]. Health care institutions are however obliged, in the face of the all the evaluations that have been carried out (which set the risk threshold at 10,000 Bq for a sewerage worker exposed

The nuclear medicine department at Nancy Brabois in figures:

– Altogether 16,000 patients are treated each year, 4,000 of them with PET scans
– 1 metabolic radiotherapy unit with 5 insulated rooms dedicated to iodine-131 treatments and taking 150 to 200 patients each year
– The department has 2 PET scanners and 4 gamma cameras
– 1 radiographic analysis laboratory. ■

1. Nuclear medicine covers all the uses of radionuclides in unsealed sources for diagnostic or therapeutic purposes. The diagnostic uses can be broken down into in vivo techniques, based on the administration of radionuclides to the patient, and exclusively in vitro applications.

2. Interviewed by Pascale Luchez.

3. Iodine-131 is a radioactive element with a very short half-life (8,02 days). Its radioactivity diminishes by a factor of 2,000 every three months. Iodine-131 is an excellent tracer for medical applications, used in small quantities for gamma scintigraphy or in larger quantities for radiotherapy on thyroid cancers. When large amounts are accidentally released into the environment (particularly by nuclear power stations), it is a dangerous fission product, because it concentrates in the thyroid.

4. Legal unit of measure for radioactivity, used internationally (symbol: Bq). This unit represents such low levels of radioactivity that it is normally used in multiples: MBq (mega or million becquerels), etc. Examples of natural radioactivity: one litre of milk, 60 Bq; one litre of sea water, 10 to 15 Bq; granite soil, 8,000 Bq/kg.

5. Because of its chemical structure, short radioactive half-life (6 hours) and weak gamma radiation, technetium-99m is one of the most widely used radionuclides in nuclear medicine and one of the least irradiating to the patient. The radioactivity administered to a patient for an examination is generally in the order of a few hundred megabecquerels (MBq).

to discharges from the exit of the sewer for 20 years without a break), to comply with a ludicrous threshold of 10 Bq per litre of water discharged, or one ten millionth of what we inject into patient.

This makes no scientific sense at all.

Contrôle : On this subject, what is your view of the new regulations on the management of radioactive effluents?

The new regulations are no more restrictive than the old; they simply have not taken account of the handful of sensible comments from professionals.

For example, for liquid effluents, if I have understood it right – and I am not certain that I have – there is the position of the ASN which could be taken as a recommendation or a warning, and there are the rules laid down by the operators of waste water networks. The ASN hides behind the operators, saying that they should know for themselves what gets into their networks. So we are asked to arrange things locally with our operators. But each of them has its own rules; there is no consistency at the national level, and no formal framework. I am very surprised that the ASN is taking a back seat on this problem and letting the network operators organize amongst themselves without imposing a bit more order.

To return to the thresholds imposed upon us: if this was just a theoretical debate, it might raise a smile, but the problem is that these regulations, however inept they may be, are enforceable and compliance has very real practical implications. I understand, for example, that if a measurement is taken at exactly the moment when a patient who has been given a dose of 20 millicuries of technetium has gone to the toilet, at this moment T, there will be a peak that exceeds the threshold. On this basis, I am obliged to build a buffer tank at a cost of € 400,000. So the ASN writes to my manager, who sees the instruction on official headed notepaper and has no choice but to obey and expend the sums quoted above.

Apart from the thresholds which I dispute, what I think ultimately matters, to safeguard the environment and the public, is the total quantity of radioactivity that I emit every day. That is the value that we need to control. The impact on the environment is after all proportional to the quantity that I discharge every day and not to the amount per litre. If I discharge 1,000 Bq per litre and the regulations limit me to 10, then it would be enough for me to dilute by a factor of 100 to stay within the rules.

But what really matters: that I discharge 10 Bq/litre 24 hours out of 24 or 1,000 Bq per litre for 1 minute and 0 for the rest of the 24 hours? The value that we are asked to measure is physically absurd. Why choose it in this case, when the experts at the ASN and their technical support at the IRSN [the French radiation protection and nuclear safety Institute] are entirely competent?

Before we close this subject, let me give one final illustration of the ineptitude of these regulations: we are told not to exceed 10 Bq per litre in discharges of technetium, while for iodine-131, which is the isotope with the longest half-life, the threshold is not 10 but 100. So we have a higher threshold for potentially the most toxic products. The ASN is not lax in this area; it simply states that we could not achieve 10 Bq per litre for iodine-131, so it has raised the threshold.

Bin for disposing of solid waste when exiting an examination room before transfer to a storage area

Contrôle : What is your view of the new rules on the management of solid radioactive waste?

At one time, we had waste management rules that were logical: health care institutions could not discharge more than so much radioactivity per day for a given category of waste. That is how we operated 10 or 15 years ago when the CHU had its incinerator. The CHU was then instructed not to discharge more than so many becquerels or megabecquerels in the various categories each day. Then we gradually moved to recycling centres for waste or public dumps. These establishments have an operating agreement with terms imposed on them by the prefect, forbidding them to incinerate any radioactive material at all, which seems sensible at first glance. Except that it does not specify anywhere whether this means natural or artificial radioactivity, and it does not mention any threshold: 1 Bq, 100,000 Bq?

In theory, these centres cannot incinerate anything at all because all substances, including natural ones, are radioactive. So it's completely absurd. Logic says that we need to be precise and set limits according to the type of radioactive element, and so be stricter on plutonium than technetium, but no-one wants to tackle this and we stick with 0.

Instead of establishing these national regulations, it was decided to prevent radioactive waste from being incinerated by installing detector gates at the entrance to every disposal facility. These start by detecting the background noise of natural radioactivity. When a truck rolls up, the level rises slightly. Above what threshold should be assume that there is a risk, and refuse to process and verify the contents? For unwritten historical and administrative reasons, it was determined that this threshold should be set at 2 or 1½ times the background level, but without explaining the scientific rationale. Everyone knows that this background level varies from one region to another, so this level of twice the background noise means that some centres can potentially accept more radioactive material than others, which is completely illogical.

4. Legal unit of measure for radioactivity, used internationally (symbol : Bq). This unit represents such low levels of radioactivity that it is normally used in multiples: MBq (Mega or million becquerels), etc. Examples of natural radioactivity: one litre of milk, 60 Bq; one litre of sea water, 10 to 15 Bq; granite soil, 8,000 Bq/kg.

5. Because of its chemical structure, short radioactivity half-life (6 hours) and weak gamma radiation, technetium-99m is one of the most widely used radionuclides in nuclear medicine and one of the least irradiating to the patient. The radioactivity administered to a patient for an examination is generally in the order of a few hundred megabecquerels (MBq).

I agree that a detector at the entrance to the incinerators is essential to prevent accidental discharges or acts of sabotage, bringing in plutonium or a 'dirty bomb', for example. But the detector alone is not enough. At the very least, it should be accompanied by a spectrometer to determine the nature of the radioactive elements and their potential danger. This sort of equipment, along with operating procedures, would allow for a graduated response according to what was detected. However, as of now, no distinction is made between 1.8 times the background level from a baby's bedding soiled with technetium and 40 000 times the background level generated by an illicit radioactive source.

There is currently just one procedure: immobilize the tanker and bring in the fire service in protective clothing, etc., even for trivial incidents. With all the false alarms, we run the risk when there is a real problem of underestimating the danger and not taking the appropriate action.

But surely it can't be so complicated to decide, for the sake of argument, that between 1 and 10 times the background level is more or less normal; between 10 and 100 is abnormal and action is needed to isolate the source; between 100 and 1,000, specialist teams should be called in; and over 1,000, you evacuate the zone. All this with decent analytical tools to determine very quickly which radioactive element we are dealing with. That is what I would call a graded approach.

I think it is the responsibility of the ASN to force the few hundred treatment centres in France to obtain this equipment and to lay down some rules. At the end of the day, I find it hard to understand that checks on radioactive waste in incinerators or in discharges at disposal facilities cannot be better organized and more graduated. We have all the resources needed to do this; why not use them? This inertia is down to the fact that the various problems raised fall under different ministries and different authorities, so everyone sidesteps the responsibility and nobody does anything.

Contrôle: What do you think of the role of the ASN in drawing up the regulations?

On a positive note, the ASN has taken the initiative in organizing formal meetings with expert groups. For example, the SFMN[6] has met with the board of the ASN on three occasions, and we take part in regular working groups to assist in developing the regulations. This is quite new and valuable. We have regular communications and identified contact persons that I can refer to when I have a problem. So it works quite well at the interpersonal level. However, despite the good intentions of our direct contacts, one feels a legal, political and administrative weight on one's shoulders that encourages a good deal of inertia and unspoken resentment, and can lead people to take the positions mentioned above in the face of common sense.

None of this makes sense to me given the ALARA[7] principle. In this principle, it is the R that matters: what do we mean by reasonable, and reasonable for whom? Nobody can say. The judge in this case is the ASN, which becomes both judge and judged as it draws up the documents and also monitors the process. In the midst of the unspoken grudges, compromises and irrational thresholds, we end up with a vague notion of what is "reasonably achievable" and set standards that are not based on the idea of radiation protection for the public and the environment but simply reflect what we are able to monitor.

Sealed source packaging, nuclear medicine department

I am not saying that there is no need for regulations, I am saying that they are badly written because they take a top-down approach by equating activities that have nothing in common, then try to distinguish as best they can between sectors, when they should address the best way of providing radiation protection in each individual area.

Here we run up against a specifically French issue: "judicial aestheticism", this French propensity for laying down universal laws. The problem with radiation protection is that this universality leads to a common approach to nuclear power stations, research reactors and nuclear medicine departments which have nothing in common either in term of elements or in terms of risks or quantities, but as the law is meant to apply to everybody, one runs into insurmountable difficulties when it comes to defining the practical aspects of applying it.

Although I am quite critical on a number of matters, I don't want to put words into anybody's mouth; I think there is a degree of willingness on the part of the ASN to move things forward, but it is bogged down in this judicial legacy that it has inherited but has also helped to create.

Contrôle: What do you think of the control exercised by the ASN, particularly by way of its inspections?

In just a few years, the ASN must have recruited almost 150 inspectors to cover the medical field ground which it has recently been tasked with monitoring. However, the training given to these inspectors, mostly engineers with industrial and

6. Founded in 1972, the Société française de médecine nucléaire et d'imagerie moléculaire (SFMN) is an association of experts which aims to promote nuclear medicine, molecular imaging and associated techniques; to organize further training and evaluation of best practice; to present a united front for the profession in negotiations with the health authorities and institutional representatives; and to engage with the major problems that preoccupy nuclear doctors. The ASN and the SFMN signed a framework agreement on 14 October 2010 on collaboration in the field of radiation protection in nuclear medicine.

7. The principle of optimization is generally referred to by the acronym ALARA: "As low as reasonably achievable".

mining backgrounds, was and is focused on power stations and other research reactors. When they are assigned to geographical areas, they are asked to inspect departments like ours about which they know nothing. As they are uncomfortable with the subject, they fall back on the checklist provided to them and are unable to take a step back and assess the situation. This means that questions with fundamentally different implications are treated alike. Still more worryingly, two inspectors from the ASN can issue us with contradictory instructions a few months apart from each other. It seems that this matter has picked up by the management of the ASN, with specific training aimed at improving the situation, but it is still a worry for us.

After the inspection, the follow-up letter illustrates this inability to prioritize the issues and risks. We end up with a list of recommendations or imperative demands (once again, it is often unclear which). Because this letter is addressed to the head of the institution, who is not a specialist in radiation protection, it often prompts him to decide upon major investments to comply with the points raised in the letter, even though some of them have no bearing on radiation protection and this compliance will involve spending tens or hundreds of thousands of euros.

I have no objection to the principle of being inspected - quite the opposite. I consider it legitimate and necessary for the society that entrusts patients to my care to check that I am doing my job and that, in so doing, I am not endangering the public and the environment. What is problematic for me is that the money spent on some activities that I consider irrelevant cannot therefore be devoted to improving the care of patients. The ASN hides behind the power of the word "nuclear" to impose measures and actions that bear no relation to the reality (or rather the absence) of the risk.

In fact, the ASN never considers the cost-benefit ratio. In the health care system this ratio is extremely pertinent. When we implement a new treatment for cancer, for example, we know the cost of each year of life gained. This may seem trivial, but when we have choices to make, it is a useful evaluation tool. Because we are in the same sort of area, it would be good to see this type of reasoning applied, i.e. what action needs to be taken to protect workers, the public and the environment against a suspected danger.

Given the dosage limits specified and applying the cost-benefit analysis mentioned earlier, we probably arrive at a billion euros per second of life gained. We end up with a system that has lost all sense. There is a kind of drift between safety and radiation protection. We end up with radiation protection for its own sake, out of proportion to the reality of the risk being run, and we protect ourselves in a disproportionate way against a level of radioactivity that is certain and measurable but carries no risk. If that just meant implementing procedures, even lots of them and all costing something, it would not be so serious, but the health care system is forced to spend enormous sums to protect against non-existent risks.

***Contrôle*: What do you think of the incidents that have occurred in connection with effluent pipes and the provision by the ASN of online incident reports and inspection letters?**

In principle, the incident report is a good thing because it allows us to look into our methods and put our equipment in order. However, on this matter of leaking pipes, the health impact is nil. The main benefit of these incidents is to show that the system is working.

Waste from processing

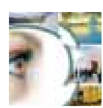
– 5 tanks holding 2,500 litres each receive the effluents from 5 lead-lined rooms in the department. Each year, some 20 m^3 of effluents are stored in these for three months as they decay.

– an average of 10 tonnes of solid waste per year (excluding iodine-131 treatment) are kept for 3 weeks in a storage zone before going to the loading platform for waste from the CHU.

– 1,000 kg per year of medical waste from iodine-131 treatments is kept in a cold store for 3 months to decay before going to the loading platform for waste from the CHU. ■

Transparency is a good principle too. It is important to know if things are going wrong. The problem is that, as the follow-up letters are drawn up at the moment, what we are given to read is completely incomprehensible. The vocabulary is both full of jargon and legalistic. It impossible for the average citizen to understand anything at all.

The follow-up letters, like the incident reports, reflect an administrative view more than anything else. You sometimes find subjects mixed up that have nothing in common, such as the maintenance of a register of 20 years old sources and the loss of a package of sealed sources intended for injection into a patient but later found in the waste cycle. In the first case, the matter was purely administrative because there had not been slightest trace of radioactivity from these legacy sources for ages, while the stray package actually contained radioactive sources. The one case was certainly an incident, while the other was just an accounting problem, but both items were mixed up in the same correspondence, artificially inflating one issue that was not an issue at all and burying a genuine one. ■



The CEA's waste management strategy

by Christophe Behar, Nuclear Energy division, Didier Dall'ava, Didier Dall'ava, Nuclear Decontamination and Decommissioning division and Éric Fillion, Nuclear Protection and Safety division – French Atomic Energy Commission (CEA)

The research role of the CEA can be seen in the Military Applications division in activities connected with nuclear deterrence, and in the Nuclear Energy division in the development of the industrial nuclear systems of the future and the optimization of current nuclear facilities in support of our partners EDF and AREVA.

The importance of the nuclear facilities and the programmes being run in them

These major research and development priorities require us to have nuclear research and support installations that we need to maintain at a high level of performance and safety and to constantly upgrade on the basis of the activities and programmes being run within them.

We need to modify and refurbish old plants, and shut down, clean out and decommission those that do not meet the needs of the programmes and the rapid changes in regulatory requirements.

To meet the needs of the scientific programmes, we also need to construct new plants dedicated to R&D, like the Jules Horowitz reactor at the Cadarache site, and nuclear facilities like CEDRA (commissioned in 2006) to hold packages of type B waste awaiting disposal, ROTONDE (commissioned in 2007) for packaging and control before transferring the packages of waste to the ANDRA repositories, and AGATE for the treatment of effluents from Cadarache, which is scheduled for commissioning in 2011.

Following the treatment plant for effluents from SACLAY and the commissioning of the evaporator in 2010, the current priority is the renovation of the treatment plant at Marcoule. The construction of a DIADEM storage facility for type B radioactive waste at Marcoule is also planned, pending deep disposal.

Waste management challenges for the CEA

Like the other stakeholders in the nuclear arena, the CEA needs solutions for managing all past, present and future radioactive waste.

An understanding of the technical, financial and chronological conditions for managing this waste is essential to enable us promptly to:
– implement safe management strategies designed particularly to minimize handling and the associated risks;
– define the packaging to be used as early as possible with a view to its ultimate disposal;
– quantify the financial resources needed and secure their availability, in accordance with the obligations placed upon the CEA by Article 20 of the Act of 28 June 2006.

The nature of the waste produced

In the course of its R&D activities and clean-out and decommissioning programmes, the CEA has generated and continues to generate radioactive waste.

The waste produced by the CEA, whether mainly solid or liquid, can be divided into two major categories:
– waste from R&D and ongoing clean-out and decommissioning operations. This waste is taken for packaging at the nuclear support facilities at the CEA sites as it is produced, to be transferred to the existing ANDRA sites or temporary storage sites;
– legacy waste, mostly stored at the Cadarache and Marcoule sites, which is being or will be gradually recovered to make up packages suitable for storage then disposal.
To a lesser extent, a similar problem is posed by:
– redundant radioactive sources used by the CEA in its own activities, and sources that it is legally obliged to recover by virtue of its past activities as a supplier of radioactive sources (up to 1986);
– spent fuel from research reactors or research into the behavior of the fuel, for any fuel not destined for reprocessing at the AREVA plant in La Hague.

Waste packaging is at the heart of the CEA strategy

Waste packaging encompasses all the operations designed to turn solid or liquid radioactive waste into a form suitable for transport and storage and disposal under optimum safety conditions.

To transform raw radioactive waste into packages of waste, various basic operations are needed:
– **classification of the raw waste:** the determination of its chemical and radiological composition and physical-chemical properties directs it to the appropriate waste management route;
– **treatment** (inset no 1) by sorting then to reduce the volume or to facilitate packaging, by inserting into a matrix;
– **placing in an envelope**, which may be a matrix (for liquid or powdered waste) or a container (for solid waste).

The current containers are made of metal or cement. Immobilizing the waste may call for a specific material, generally bitumen or cement. The choice of the different elements is based on the character and shape of the waste after treatment.
– **classification of the package** (inset no 2) made up according to the specifications defined by ANDRA and approved by the ASN.

Route for removal to the two existing repositories:

Route for very low level waste: VLLW

The day-to-day output from the R&D plants, the clean-out and decommissioning sites and the recovery of legacy waste

Inset 1 :
CEA Cadarache: treatment plant for effluents and solid waste

INB 37 (treatment plant for effluents and solid waste) comprises two units:
– the treatment plant for effluents, to be replaced by INB 171 "AGATE" in 2011 ;
– the treatment plant for solid waste; since the commissioning of ICPE 801 "ROTONDE" in 2007, this now only receives compactible radioactive waste that cannot be disposed of on the surface. This flow of long-lived LL-ILW is split into two branches: low radiation (less than 2 mGy/hr contact) and intermediate radiation (between 2 and 10 mGy/hr), compacted under the same pressure of 500 tonnes then injected with mortar, before being removed to INB 164 "CEDRA" which holds them pending deep disposal.

Intermediate radiation ILW-LL

This waste comes mainly from the decommissioning of the plants at Grenoble and Fontenay-aux-Roses, and from the ongoing operation of the Cadarache facilities. It is collected from the original producers in metal drums of around 50 litres each, and then transported to INB 37 in suitable packaging (RD 30-31, DGD-001).

Cadarache nuclear installation No. 37 (INB 37) - 500 tonnes pressure to compact LL-ILW waste

Low radiation ILW-LL

This waste comes mainly from the decommissioning of the installations at Cadarache, and from the ongoing operation of the Valduc and Cadarache facilities. It is collected from the original producers in metal drums of 100 litres each, and then transported to INB 37 in suitable packaging (RD 39).

Traceability of packages of waste; the Caraïbes software

The packages for long-lived intermediate level waste (500 litres intermediate radiation, 870 litres low radiation) are packed under permits issued by ANDRA, which cover the inclusion of these packages in the deep disposal programme. Compliance with the permits issued by ANDRA requires complete and reliable traceability of the nature of the waste and the package produced. This is provided throughout the transfer of the waste by the "Caraïbes" computer system.

generate a large quantity of very low-level waste to be taken to the repository at Morvilliers.

The CEA sends the equivalent of 12,000 to 15,000 m^3 of waste per year in the form of approved packages.

The challenge for the CEA is to maintain an industrial process optimized in a technical and economic sense. The waste from nuclear waste zones is overwhelmingly (80%) waste that is not radioactive or registers no significant radioactivity (no measurable radioactivity or values below the IAEA and EC emissions thresholds) and for which there is no ideal solution (inset no 3).

An average of four transfers a week are made by road and rail between the CEA sites and the Morvilliers centre.

Route for short-lived low and intermediate level waste: SL-LILW

The operation, maintenance and clean-out of nuclear plants generate 5,000 m^3 of short-lived low and intermediate level waste every year, which is transferred (in one road shipment each week) to the Aube repository in the form of packages approved by ANDRA.

The challenge for the CEA is once again to maintain a procedure managed in an industrial way with consistent specifications for the packages of waste, so that the CEA can optimize the type and number of packages to be disposed of without compromising the quality-assured production process for the packages.

Recycling is the preferred option where the technical and economic situation allows.

The recycling of crushed scrap metal and concrete is one of the major elements of an improved industrial process and should help to slow the filling-up of the VLLW repository.

The CEA has developed a procedure to recycling VLL lead from its own nuclear plants with two industry partners.

AREVA and EDF also use this route for their own needs.

Issues with an underground repository for SL-LLW and a deep repository for LL-ILW and LL-HLW

SL-LLW, LL-ILW and LL-HLW from R&D and clean-out and decommissioning programmes are held in dedicated facilities run by the CEA.

With regard to the recovery of legacy waste, Article 7 of the Act of 28 June 2006 stipulates that the owners of LL-ILW produced before 2015 must package it up by 2030 at the latest.

The CEA's strategy is to effect this packaging in packages compatible with the facilities for storage on CEA sites and with future disposal.

Pending the availability of procedures for disposing of LL-ILW and LL-HLW, the CEA has two types of storage:
– old storage sites that do not fully comply with current safety standards. Plans for recovering the waste are based on the availability of future disposal routes and on safety priorities;
– more recent storage sites (particularly CEDRA on the Cadarache site), which meet current safety standards and accord with the programmes and projections for the output of

waste from R&D and clean-out and decommissioning operations.

For these projections, the CEA uses the ETE-EVAL software originally developed by AREVA. The PHÉNIX reactor, even before it stopped producing electricity, was the subject of a detailed evaluation of the waste that would be generated when it was cleaned out (type and likely quantities) and the associated storage needs.

The challenge for the CEA in relation to future repositories, as for the existing procedures, is to ensure:

• that all radioactive waste finds its way into stable routes

For waste already produced and awaiting disposal, packaged according to the specifications approved by ANDRA, the CEA would like to see these packages accepted as they are with a minimum of additional containers; this is the only way not only to enable technical and economic rationalization but also to address the risks associated with handling and radiation protection of the staff on site.

The recent issues concerning things like the management of hydrogen produced by radiolysis in some packages of waste should be the object of a technical and economic approach for future waste and for the packages to be produced, in order to minimize the quantity of hydrogen generated, even though the

Inset 2 :
Non-destructive nuclear measurements applied to packages of waste

Research and development of methods of non-destructive nuclear measurement are led by the Nuclear Measurement Laboratory of the Nuclear Energy division. This laboratory, run by the Nuclear Technology department, is also a centre of expertise for "Nuclear Measurements" for the Nuclear Protection and Safety division.

The methods developed and implemented in the CEA's nuclear plants, applicable to packages of radioactive waste, are designed:

– for physical classification (figure 1): transmission, radiographic and tomographic imaging, to measure the softening or the density of the material, identify and localize any defects and analyze the matrix of waste in order to interpret the radiological measurements;

– for radiological classification: measurements of α and $\beta\gamma$ radiation, measurement of fissile mass by gamma-ray spectrometry and/or active or passive neutron measurements;

– for elemental classification by the use of neutron or photon analysis (thermal neutron capture, inelastic diffusion with D-T neutron generators with associated particle tube, etc.) aimed at grading stable or low-emission radioactive elements (LLRNs, neutrophages, chemical toxins, etc.).

The priorities for developing and enhancing the methods are principally interpreting and analyzing the signals, managing uncertainties and linking methods together (neutron and gamma, physical and radiological).

In connection with evaluating methods and systems and providing expertise, the laboratory has specified and designed high-performance measuring equipment and cells that are in operation in nuclear plants on the Cadarache site. The objective of classifying waste as close as possible to its place of production has logically pushed the studies towards developing and designing portable measurement systems.

High-energy rapid imaging bench for physical classification of waste packages - Radiographic and tomographic imaging with linear electron accelerator and 2D wide field screen

Inset 3 :

Radioactive materials or waste, and waste from nuclear waste zones: definitions and clarifications

In the CEA's view, the recasting of the regulations initiated by the ASN should prompt us to question the practice of classifying non-radioactive waste as "nuclear waste".

Hence, the decisions of the ASN, which will influence the future INB decree, should be drawn up in accordance with Programme Law no 2006-739 of 28 June 2006 concerning the sustainable management of radioactive substances and waste, since enacted in the Environmental Code, to use the following terms:

– **radioactive substance:** *"substance containing natural or artificial radionuclides, where the level of radioactivity or the concentration justify radiation protection checks"*;

– **radioactive waste,** for waste that really is radioactive, i.e. *"radioactive substances for which no subsequent use is planned or envisaged";*

– **waste from "nuclear waste zones",** in place of the previous terminology ("nuclear waste") dating from the Decree of 31 December 1999 laying down the general technical regulations aimed at preventing and limiting external hazards and risks arising from the operation of nuclear installations, which is to be repealed.

This semantic rigor would help to clarify the fact that not all waste from "nuclear waste zones" is radioactive and that some, after the appropriate checks, should be able to move into the routes for managing conventional, i.e. non-radioactive waste.

Moreover, the discussions preceding the adoption of the Act of 28 June 2006 indicate the desire of the legislature to provide the owner/holder of a radioactive substance with genuine autonomy when it comes to deciding not to reuse it, and hence to treat it as waste. It is therefore unnecessary for this "subsequent use" to be "planned" (and still less for proof to be provided), but only necessary for it to be "envisaged".

The CEA wants to see a rigorous regulatory framework maintained within nuclear installations for the management of radioactive waste, in such a way as to guarantee a **strict separation** between the procedures to manage this radioactive waste and those devoted to conventional waste. This rigor would not run counter to an industrial approach to these procedures, or their development and optimization.

Finally, the scarcity of the resource represented by a repository for the ultimate radioactive waste, emphasized by successive National Radioactive Material and Waste Management Plans (PNGMDRs) should prompt the administrative authorities to establish a regulatory framework to promote the economical use of these repositories and hence the **recycling of non-radioactive substances,** particularly the large quantities of scrap, precious metals, concrete and rubble produced when the plants are decommissioned.

Over and above this initial approach, the CEA believes that the regulations put in place should not prevent France from acquiring tools in the medium term to allow some waste to be disposed of, in the same way as most of the other countries concerned.

CEDRA (packaging and storage of radioactive waste) facility for radioactive waste (nuclear installation No. 164). Arrival of a transport cask and receipt operation for waste packages

production of hydrogen is inherent in the waste material concerned.

• Approved specifications for preparing the packages

To improve the management of the waste to be produced, it seems essential to establish specifications by 2015 for the reception of the packages and the packaging options to allow this waste to be handled in the future, while enabling interim storage under safe conditions.

• Predictable costs and plans

The CEA, along with the other nuclear operators, should define the technical options, costs and schedules for all the operations that produce waste and for the treatment of this waste.

Definitive technical specifications and reliable estimates of the costs of handling the waste are essential if we are to make the technical choices and plan the various clean-out and decommissioning operations required to obtain the funding in accordance with Article 20 of the Act of 28 June 2006 on waste management.

Future-proof solutions

Waste is not an inevitability; the nuclear industry manages its waste, aims to reduce the quantity and limits its radiotoxicity in appropriate packages.

Future-proof solutions exist, and the CEA is coordinating research into the transmutation of long-lived radioactive elements.

This research, which forms part of a longer-term strategy, involves studying the processes of separation and the means of transmutation of minor actinides (which are the main contributors to short-term thermicity and radiotoxicity beyond several centuries of disposal).

The results obtained at the laboratory level for the separation of actinides, and in experimental reactors for the transmutation of americium in particular, already demonstrate our ability to very substantially reduce the radiotoxicity of the waste earmarked for medium-term deep disposal. ■

Management of the radioactive waste generated by EDF's nuclear power plants in service

by Bertrand Lantes, Nuclear Production division, and Stéphane Beguin, Nuclear Fuel division – EDF

Operational management principles

Since the launch of its first nuclear power station, EDF has established an industrial process to manage its waste, which is being continuously enhanced to reflect changes in the regulations and the available technology. This management, reinforced by feedback from experience, enables it to handle the risks of exposure at every stage, from production to final disposal.

The guiding principles now applied by EDF to the sustainable management of its waste are as follows:
– limiting the quantities, first from production, then by recycling and treatment;
– sorting by type and level of radioactivity, to tailor the treatment and packaging, then long-term management;
– packaging directly from production, to avoid any risk of spreading radioactivity;
– storing the packages in conditions that do not compromise their integrity, to manage the decay of radioactive waste in the absence of disposal routes;
– transportation then disposal, to safeguard people and the environment by erecting man-made or natural barriers for a sufficient period for the radioactivity to decay.

When it comes to short-lived waste from the operation and maintenance of working plants, EDF now has complete industrial management solutions undergoing constant optimization with its partners in industry and R&D.

The waste in question: sources and type

EDF's 58 pressurized water reactors (PWRs) were commissioned over the period from 1977 to 2001. They have now logged almost 1,500 reactor-years, with an average age of 25 years. The waste produced by the operation of the EDF plants falls into the category of "short-lived" waste:
– very low-level waste (VLLW); around 2,500 m^3 produced each year;
– low or intermediate level waste (LILW); around 5,500 m^3 produced each year.

The volumes quoted above are, by convention, those of waste placed in the packages disposed of in the corresponding ANDRA repositories: CS TFA (for very low level waste) and CS FMA (for short-lived low and intermediate level waste). We also speak of volumes of "raw" waste, i.e. before treatment and packing in disposal packages.

The total radioactivity declared by EDF's production sites in the 38,941 "VLLW" and "LILW" packages produced in 2009 was 254 TBq.

Waste in the "LILW" category from the nuclear power plants is generally grouped into two categories according to its source: so-called "technological" waste, from operations and maintenance, represents the bulk of the volume (84% of "raw" waste produced each year) but it is the least radioactive (0.3% of the declared annual radioactivity).

Conversely, the most radioactive waste falls into the category of "process" waste: this comprises filters and ion exchanger resins used to purify the cooling water. This waste represents 90% of the declared radioactivity but only 3% of the total volume of "raw" waste.

The remaining waste, which accounts for something like 10% of the declared radioactivity and 13% of the volume of "raw" waste, has a specific activity on the border between low and intermediate level and is mainly made up of:
– evaporator concentrates from the treatment of used effluents, whose borium content (the moderator in the main primary circuit) can reach 50 g.L-1;
– radioactive sludge recovered from the bottom of tanks and in the sumps under the reactor block.

The levels of production of process waste are relatively stable, while those of low-level technological waste vary according to the volume of maintenance activity. From 2015, the number of ten-yearly visits to 900 MW (VD4) and 1,300 MW (VD3) reactors will be reflected in an increased "volume" of projects. In anticipation of this, the operators are preparing to manage these increased volumes by way of operating guidelines for the transit zones (sorting, classification, packaging) and storage areas for the packages before shipment. A projection of the production flows associated with maintenance operations over a period of three years also allows us to better anticipate the management resources required in the medium term.

Limiting the quantities of waste: at source, by treatment and by recycling

The continuous progress made in the design of the plants, the management of the fuel and the operation of the installations has enabled the annual volume of waste to be cut by a factor of four in just over twenty years, for the equivalent energy production: 13 m^3/TWh in 2009 against more than 51 in 1986.

In the same period, the average radioactivity, excluding tritium, of the liquid effluents discharged into the environment from the sites has been reduced by a much greater proportion, as a result of increasing control over the process (reduction at source of spent effluents). With the optimization of the treatment methods, the most significant results in terms of production have been obtained with process waste: filters, ion exchanger resins and evaporator concentrates.

At the time of the first ten-yearly inspections of the 900 MW reactors, the production of technological waste was reduced by optimizing the sorting and packaging, particularly by compacting on site and also by the super-compacting process developed in the early 1990s at the Bugey nuclear power plant, before the waste was moved to the ANDRA LILW repository.

Today, most nuclear power stations are equipped with the means of compacting low-level waste, which helps to limit the volumes stored and reduce the number of shipments to the processing and disposal facilities. For example, the air filters and lagging materials intended for the LILW repository are cut up and crushed before being pre-compacted in 200 l metal drums (around 5,000 drums a year). Combustible technological waste also undergoes compacting on site, directly into 200 l plastic drums.

These advances have been achieved by adapting the technical resources, and above all by increasing the professionalism and accountability of the stakeholders. These arrangements, now well-established, concern things such as:
– the inclusion of waste management in the site management contracts (objectives and results) and monitoring of their performance by way of indicators, feedback from experience or the identification and general implementation of best practices;
– the establishment of operational structures on the sites to coordinate and raise awareness of waste management in all departments, formalized a few years later by ISO 14001 certification;
– the creation of specific "waste management" training.

The actions aimed at the different professions concern both EDF staff and service providers in the area. Since they were launched in the early 1990s, the content of the training courses has evolved constantly to reflect the deployment of new processes, new installations on site, new routes and regulatory changes. Involving the different professions is especially important today in the interest of renewing skills, where it is contributing to the rise of a new generation of waste managers.

Despite this continued progress in limiting the quantities of waste, the volumes of "raw" technological waste increased by 50% between 1995 and 2009. Indeed, maintenance operations, modifications associated with bringing fixed nuclear plants into line with the general technical regulations (RTGE), and other actions to keep the installations in working order have been reflected in a new stream of items to be scrapped and of various materials (paint pots, vinyl, overalls, etc.) to be disposed of as radioactive waste because they come from nuclear waste zones. Since 2005, some new measures have nevertheless been taken to reduce these at source:
– technological waste: management of "consumables" (films, bags, individual protective equipment) at the maintenance sites, use of shrink wrap to package objects instead of thick PVC film, use of rigid mats and screens instead of PVC films, etc.
– process waste: some encouraging results have been obtained with the production of ion exchanger resins by not replacing them when they reach the limits of their capacity. Because of radioactive decay (the spent resins are stored for several years), this optimization has no effect on the exposure of the operators responsible for packaging the waste;
– optimizing the contamination zones at the plants has enabled a reduction in the output of radioactive waste by way of improved classification. For example, although they come from controlled zones, rubble and metal waste have been disposed of as conventional waste.

When it comes to reducing the volumes of waste disposed of at the LILW repository, there was a major development at the end of the 1990s with the commissioning of the CENTRACO plant by SOCODEI, a specialized subsidiary of EDF. This plant, comprising an incinerator for low-level waste and a melting furnace for mildly contaminated scrap metal, has allowed us to institute a voluntary policy of reducing the ultimate volumes of waste, and hence to offset increases in the output of raw waste. A significant proportion of the waste produced by EDF plants is now sent to CENTRACO:
– metal waste (valves, pumps, tools, etc.) and non-ferrous metals are melted in an electric induction furnace at 1,600 °C. Some of the material obtained, in cast form, is recycled into radiological protection collars for the concrete containers, avoiding the equivalent consumption of new materials; the final waste, in the form of ingots, occupies just 10% of the volume of the original scrap;
– combustible solid waste (gloves, overboots, work overalls, plastic film, paper, rubber, etc.) and liquid effluents (cleaning solutions, oils, solvents, etc.) is incinerated; when the initial volume has been reduced to reasonable proportions, of the order of one tenth or one twentieth of the original volume, the final residues are packed in solid form, chemically stable and non-dispersible, suitable for final disposal. Some effluents and very low-level soda are used in place of raw materials normally used in the process.

In this way, in ten years of operation at CENTRACO from 1999 to 2008, 30,000 m^3 of low-level metal waste and 43,000 m^3 of combustible waste from the PWR plants were treated by melting and incineration, enabling savings of 64,000 m^3 in the low-level radioactive waste to be stored, or the equivalent of nine years of use by EDF of the LILW repository.

The use of CENTRACO also enables us to manage the waste from specific maintenance operations: from 2010, for example, the programme to "re-rack" the Bk pools in the CPY stage will use the melting functions to process the bulk of the old decommissioned racks (see photo above).

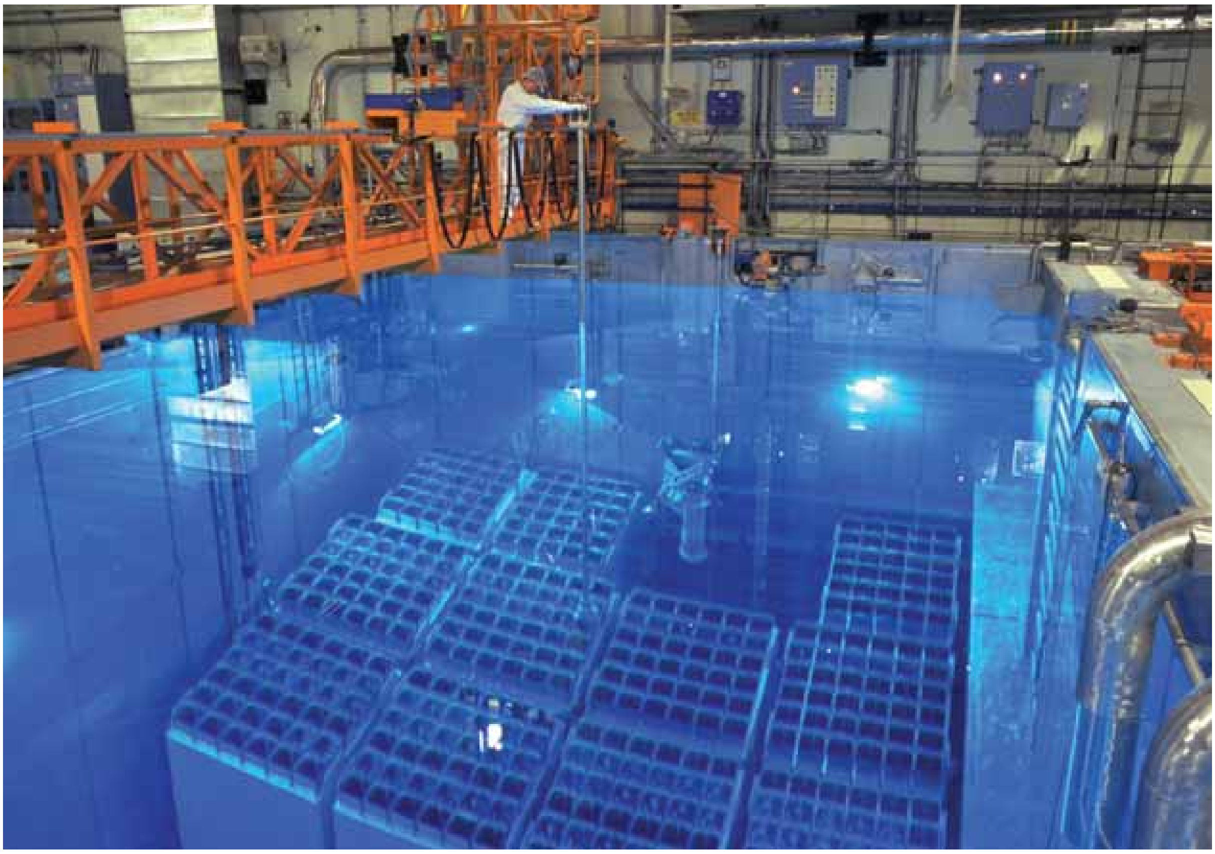
The commissioning of the CENTRACO plant has also allowed some waste to be treated that used to have no management route and which sometimes remained stored on site. In this way, several thousand tonnes of oil and solvents and various types of aqueous, humid and fatty waste have been eliminated.

Sorting operations: by type and level of radioactivity, as close as possible to the sources of production

The optimization of waste management at all stages, from production to final disposal, requires selective sorting according to environmental, dosimetric and economic criteria. The sorting operations are more effective if they are carried out early and in a planned way: the operating manual therefore lays down instructions for sorting waste as close as possible to the processes that produce it, to minimize the risk of later mixing and facilitate the management of this waste.

The sorting is first carried out according to radiological criteria (dose rate, specific activity), enabling the waste to be routed into the appropriate routes. VLL and LL technological waste is then pre-sorted by physical composition, in the areas that produce it inside the reactor block. This sorting process is used, for example, to eliminate combustibles (wood, paper, cardboard, plastic, etc.) as early as possible, or to select any waste whose volume can be reduced by treatment in place.

The specific requirements of the treatment (CENTRACO) and disposal (ANDRA) routes then represent major sorting criteria, helping for example to distinguish prohibited waste (liquids, fats, aluminum, etc.) or to select waste according to size (thickness of very low-level scrap metal items).



Racks in Bk pool comprised of cells for storing spent fuel

Once it has been sorted, the raw waste is quickly pre-packaged in the appropriate containers (plastic bags, metal boxes, sealed drums, etc.) and collected in dedicated zones within the reactor block for a limited period, before being placed in sealed containers ("containment" tanks) for transfer to the intermediate storage buildings.

Packaging: in-line management to address the dosage constraints

On the production sites, most of the processes for packaging radioactive waste are implemented by way of fixed equipment provided by the design of the plants. These are mainly:
– 25-tonnes presses to compact bags of low-level waste into metal or plastic drums, to be sent directly to the LILW repository or to CENTRACO;
– packaging cells in which intermediate-level waste (technological waste and water filters) is sealed/wrapped in a cement matrix directly in concrete hulls.

The ion exchanger resins, on the other hand, are packaged by two mobile units (MERCURE 1 and 2) operated by SOCODEI (see photo). This involves wrapping the resins in an epoxy polymer matrix, directly in concrete hulls.

Other equipment has been added to the range of available processes, particularly to compress the waste, such as shredders, machines to cut up and crush low-level waste, and mobile packaging systems for evaporator concentrates and sludge in the packaging cells in the 1,300/1,450 MW plants.

Despite its low level of radioactivity, the management of "technological" waste imposes greater constraints on operations than "process" waste. The operator will opt for "in line" packaging by organizing the collection, sorting and pre-classification of this waste as early as possible in order to keep the premises free from contamination and minimize the risk of spreading radioactivity. The lack of space in a reactor block, particularly during temporary shut-downs that generate peaks in waste production, also prompts operators to organize a rapid process to facilitate "online" disposal of the waste.

On the other hand, the control of radioactivity levels by the operators is one of the technical criteria that may cause them to defer the packaging of some "process" waste for a time to allow for radioactive decay, particularly for resins from the primary cycle. Hence, ion exchanger resins are packaged in "campaigns" at three to four year intervals.

The objectives of "online" treatment demand a high level of availability of the plant and equipment used in the different phases of packaging: a programme of renewal of this equipment (hoists, compacting press, etc.) is in hand in all the plants.

Storage: an intermediate stage to manage the availability of the routes

The packages of LIL waste awaiting removal to the CENTRACO treatment routes or disposal in the LILW repository are held in buildings designed for this purpose: auxiliary packaging buildings (BACs) and effluent treatment buildings (BTEs).
These storage areas are operated according to a detailed manual which defines the management rules. For example, "storage plans" are drawn up to manage the risks relating to safety, radiation protection and fire. Despite their relatively large capacity to handle the number of packages that may need to be held, the aim is to manage the storage at a low level,

disposing of the packages as quickly as possible. This principle helps especially to manage the peaks in output (shut-downs, packaging campaigns for ion exchanger resins or sludge) and the temporary unavailability of the routes.
The management of storage in the BACs and BTEs was simplified from 1998 onwards by the initial creation of "temporary" storage areas for VLLW, followed in 2002 by "long-term" VLLW storage areas with more rigorous structural requirements and run according to detailed rules. In fact, more than 10,000 tonnes of waste have been transferred to these areas:
– solid waste in a "double envelope" (drums or boxes inside containers) pending the commissioning of the LILW repository;
– oils and solvents which are now only stored for work in progress, with the waste being incinerated online at CENTRACO.

Transport

Shipments of short-lived radioactive waste from the nuclear power plants to the treatment centres and repositories are mainly taken by road. Around 1 200 shipments of waste packages from plant operation are organized every year, from the power plants to CENTRACO, and to the VLLW and LILW repositories, in conditions of maximum safety to safeguard workers, the public and the environment.

The vast majority of the packages transported are taken away in standard containers and trailers. A few kinds of high-volume waste do however demand special measures, such as the 55 tank reactor vessel head that have been progressively dispatched to the VLLW repository since 2004 (6 per year), to be disposed of in dedicated structures. These reactor vessel head weigh between 57 and 80 tonnes depending on the levels; the final packages (cover, biological protection and containing envelope) weigh between 87 and 120 tonnes.

Twelve out of 19 sites are connected to the rail network, which also allows radioactive waste to be transported by rail to the terminal at Brienne-le-Château, in the Aube, where the packages and containers are taken by truck to the repositories operated by ANDRA. Around 60 shipments are carried in this way each year, and this mode of transport could be developed in the medium term to connect the repositories to the rail network: discussions have begun with ANDRA and the rail operator on conditions favourable to this development.

Final disposal

The packaged waste is finally taken over by ANDRA, which handles the design and operation of the repositories, providing immediate and longer-term protection for the environment and for people. Two repositories are currently in operation, one for VLLW (CS TFA, at Morvilliers in the Aube) and one for LILW (CS FMA, at Soulaines-Dhuys, also in the Aube).

The long-term safety of the LILW repository is maintained by three barriers: the waste package, the disposal facility and the geological barrier. In view of their role as a barrier, the packages of waste are therefore packaged by EDF according to precisely defined acceptance criteria that are regularly checked by ANDRA.

According to the national register published by ANDRA, deliveries of LIL waste made by EDF to the Manche repository until it closed, then to the LILW repository up to 31 December 2007, represent a total volume of 348,500 m^3, or 47% of the total deliveries received by the repositories from all producers together.

Mobile MERCURE units used for packaging ion exchanger resins in concrete hulls

Conclusion: a complete industrial management process for waste from the operational plants

The last decade has seen substantial progress with waste that could not be accepted by the existing repositories because of its physical or chemical properties. Some sealed spent sources with a high level of radioactivity and/or based on long-lived radionucleides, which are unsuitable for disposal at the LILW repository, are now the only category of waste without a management route.

Today, practically all the radioactive waste produced by the operational plants therefore has a complete and final management route, providing long-term protection for people and the environment.

Finally, EDF is playing an active role in the work on the National Radioactive Material and Waste Management Plan (PNGMDR), both in research into dedicated management solutions for waste without any route and in research into the overall medium-term optimization of the management routes, e.g. to limit the volumes of "final" waste for disposal. ■

WASTE MANAGEMENT STRATEGIES FOR WASTE PRODUCERS

AREVA's waste management strategy

by Philippe Poncet, waste and decommissioning specialist, Safety, Security, Health and Environment department (D3SE) – AREVA

The nuclear activities of the AREVA group cover the whole nuclear fuel cycle, from extracting the uranium ore to recycling the spent nuclear fuel, taking in the design of the reactors and the associated activities. It is therefore involved in research, extracting and concentrating the uranium ore, converting and enriching the uranium, designing and manufacturing the fuel, designing and building reactors, supplying products and services to the nuclear power plants, recycling spent fuel, supporting and managing projects in a radioactive environment, operating nuclear sites and transporting radioactive substances.

All these activities naturally produce waste, particularly various kinds of radioactive waste.

Limiting the impact on people and the environment

Although any activity is bound to produce waste, AREVA has set itself the target of always trying to reduce this waste, in terms of quantity and harmful effects. This is an ongoing process, starting with the definition of a project and continuing throughout the life of a plant, as well as in all service activities to its customers. The actions designed to limit and control the impact of radioactive waste on people and the environment can be divided into three main areas:
– reducing the volumes;
– packaging;
– managing storage facilities and transfer into the authorized routes.

These affect all radioactive waste of every kind, generated and managed during activities at every stage in the life of the installations and equipment that use radioactive materials (design, construction, operation, maintenance, shut-down, decommissioning, recovery of legacy waste, etc.), throughout their geographical extent (buildings and foundations, external areas, land, underground areas, rubble, soils, etc.), and at all the sites where the AREVA group operates.

They also affect the by-products awaiting specific treatment at any stage in the fuel cycle, and non-nuclear activities involving processes that concentrate natural radioactive elements (such as the treatment of zirconium ore).

The same applies to activities connected with service provision, in consultation with the customer of course, who bears the responsibility as the holder of a license to operate the installation. This aim forms part of an overall policy laid down in the "principles for action" in AREVA's nuclear safety charter.

An internal directive addressed to all of the operational units capable of producing radioactive waste summarizes the objectives and specifies the resources to be deployed in terms of organization and implementation, to provide for the safe management of radioactive waste in line with the sustainable development of the group. In particular, it sets out areas of action concerning:

Storage of waste at AREVA's fuel production plant in Lingen (Germany)

– the strict separation of conventional and radioactive waste;
– their end-to-end management;
– the deployment of advances in the field;
– the risks associated with transport;
– the containment and concentration strategy;
– the use of every final disposal route.

Knowledge and expertise are also covered, with each establishment called upon to appoint a radioactive waste officer. This person monitors the activities concerned, and contributes to the exchange of experience within the group as a member of a network headed by the "radioactive waste and decommissioning" specialist in the Safety, Security, Health and Environment department (D3SE) of AREVA. The identification of risks and changes in regulatory requirements are always a focus of attention at the discussion meetings.

Identifying and classifying radioactive substances and waste

Law 2006-739 of 28 June 2006 on the sustainable management of radioactive materials and waste defines final radioactive waste as "radioactive waste that cannot be treated under the present technical and economic conditions, particularly by extracting its usable content or by reducing its polluting or hazardous character".

The residues and by-products from the operation, maintenance, decommissioning and clean-out of installations may be subject to the same management, depending on their radiological and physical properties. These residues and by-products mainly undergo treatment and recycling operations aimed at recovering as much as possible. In this sense, they are not necessarily classed as waste.

Moreover, the activities to treat spent fuel on behalf of electrical customers involve packaging the waste belonging to them (mostly long-lived intermediate and high-level waste), which is returned to them after storage pending chilling to enable it to be transported safely.

The radioactive waste and other materials are monitored, classified (by type, volume, radioactivity) and checked to ensure that they are fully identified and to optimize their management. Technical resources are deployed to address the generic problems such as the problem of mixed waste. For example, the treatment of neons from radioactive waste zones enables the recovery of mercury vapor and the packaging of glassware and metal end-pieces in nuclear waste. Financial resources are also earmarked for research into routes for waste that do not yet have any. This is the case, for example, with contaminated oils which cannot be accepted in the SOCODEI incineration plant.

Defining ways of reducing operational radioactive waste before the plants are designed

Actions to address the objectives to reduce waste are included in the initial phases of industrial projects (the Georges BESSE 2, EPICURE, COMURHEX 2, TAO plants, etc.), and throughout the life of the installations. They are reflected especially in:

– the incorporation of feedback from the design phase onwards, particularly in the choice of materials and processes;

– the completion of specific studies and the establishment of waste zones (for plants located in France);

– the identification of routes for recycling wherever possible, or for disposal for exotic waste;

– discussions held in partnership with the organizations responsible for disposing the waste (in France, ANDRA).

Inter-entity meetings within the group, organized periodically by the general inspectorate as part of the work of the network of "radioactive waste" officers, facilitate operation and information sharing in these areas, and the general deployment of technical, organizational and human resources. This is particularly true of research into solutions for waste that has no route, the optimization of methods of classification and packaging and the development of traceability tools. Central coordinators from the CEA and EDF are now invited to internal meetings of the network, to broaden the scope of the debate and share the benefits for common concerns.

Reducing our footprint by improving the organization

A specific work organization can help to reduce the volume of radioactive waste generated during operation and maintenance work on the installations. This involves:

– carrying out most of the operations in areas whose radiological cleanliness permits the generation of conventional waste (classified in France as "conventional waste zones") rather than in zones likely to generate radioactive waste; this means, for example, unpacking the materials needed for an operation before entering the controlled area rather than after, which makes the packaging into conventional waste rather than VLL waste;

– reducing the number and duration of operations carried out in nuclear zones in order to reduce the direct and indirect exposure of the staff;
– improving radiological cleanliness.

The overall effect on people and the environment of activities associated with the management of radioactive waste is then reduced.

In France, developments in waste zoning that favor the maintenance of radiological cleanliness and allow the conventional waste zones to be expanded are helping to move this forward.

During operations that carry a residual risk of spreading radioactivity, specific operational procedures provide for temporary zoning (called "operational zoning"). To do this, a predefined organization plans a shift in the lines of defence and safeguards the traceability of these changes and the checks carried out, to guarantee that there is no contamination in conventional waste zones.

In countries where the regulations allow the status of radioactive waste to be changed, decontamination activities are carried out if they are likely to produce an overall benefit, taking account of the relevant parameters regarding:
– the safety of waste management;
– the overall impact on the environment;
– the economic costs of operation.

Limiting the volume of radioactive waste naturally limits the footprint of industrial activities by reducing the impact of:
– operations to package the nuclear waste; – of transport to the repositories;
– the consumption of "resources", made up of the installations and the management and monitoring of waste disposal;
– the storage areas at installations for waste awaiting removal.

The AREVA group has a tool to monitor and evaluate the environmental impact of its activities, with specific indicators for the management of radioactive waste and the decommissioning of installations. The trend in these indicators shows:
– significant progress (> 50 % over 4 years) in online disposal of radioactive operational waste;
– a drop in the volume of radioactive waste stored while awaiting entry into the appropriate route;
– an increase in operations to recover waste (RCD).

The actions that have enabled this progress mainly concern the management of the waste, with "just in time" disposal, and treatment of historical waste for which there was limited capacity (VLLW in particular).

Under the regulations, the waste is classified according to the level of radioactivity (in France, there are four levels: very low, low, intermediate and high), and according to the half-life of the radioactive elements that it contains (very short, short or long-lived). The packaging is tailored to these properties. It broadly determines the safety of storage, transport and disposal. However, the packaging is not always the only physical means of containing toxic substances. It is itself incorporated into a package for transportation, and held in a shed or building for storage or disposal. These physical aspects are supplemented with organizational measures.

Checks are performed to confirm the effectiveness of the treatment and packaging of the waste, and these activities are part of the quality assurance systems in the entities designed to ensure that the waste is properly conditioned. The results are made available to the bodies responsible for their final management (such as ANDRA in France). The activities handled by service providers which are liable to affect the quality of containment of the waste are subject to special requirements, and undergo recorded monitoring and inspection carried out by the entity itself at several levels. Efforts to standardize these procedures within the group have been initiated in periodic meetings of the group's radioactive waste officers.

Loading drums of incinerable waste at the site in La Hague for the CENTRACO plant

Treatment process

Nuclear waste from AREVA plants is treated in specific installations within the establishments concerned, or passed on to partners who have the appropriate equipment. It involves, as a minimum, the following operations (in the order given):

– isotopic classification and measurement of radioactivity (to tailor the packaging to the level of radioactivity);

– reduction and/or alteration of geometry (cutting up);

– packaging in containers suited to the nature and radioactivity of the waste (e.g. VLLW = big bag, LLW = metal drums, HLW = stainless steel packages containing vitrified waste).

A quality control programme is executed throughout the treatment process. The packaged waste makes up a package of waste. ■

Reducing the quantities of waste in interim storage, and removal into approved routes

The packages of waste can only be held in accordance with the "waste acceptance specifications" specific to the storage area concerned. These are defined by the operator, in the light of the safety requirements for interim storage laid down in the technical instructions from the ASN. The contents of storage areas for radioactive waste must be completely known and managed at all times: the locations, the physical placement, quantities and characteristics of the waste, the storage conditions, monitoring and traceability, etc. The integrity of the packages and any changes to them are subject to checks within each storage area, with the frequency of these checks calculated to maintain continuity in the arrangements guaranteeing the safety of the whole. The objective of reducing the quantities held in this way remains paramount, despite a significant reduction in the operational waste stored. The disposal of radioactive substances and exotic waste always depends on the existence of disposal routes for the packages of waste to be permanently disposed of. Specific research programmes have been initiated to provide disposal routes for waste for which none has so far been defined. This process is in line with the National Radioactive Material and Waste Management Plan (PNGMDR) for 2010-2012.

In its plant at La Hague, AREVA now has an online packaging process for almost all of the waste associated with the treatment of spent fuel. Some waste, mainly long-lived intermediate-level waste, used not to be covered by performant packaging methods with an operational final disposal route, owing to lack of knowledge. AREVA now has a dedicated organization in the form of the Recycling business unit, one of whose priorities is to recover and package this legacy waste, particularly from the operation of plant UP2 400, by 2030, in accordance with Article 7 of the Act of 28 June 2006.

This organization aims especially to:

– look into the technical and financial synergies with future processes that are likely to play a major role in the treatment and recycling of future fuels;

– anticipate the constraints on disposal by initiating R&D programmes together with ANDRA to build up the relevant knowledge and avoid any fresh repackaging operations;

– minimize the volumes of packages by favoring compaction or concentration/vitrification processes wherever possible;

– direct technological waste into existing disposal routes wherever possible, by initiating any decontamination operations that may be needed.

Efforts to recycle waste metal to conserve natural resources

The 2010-2012 edition of the National Radioactive Material and Waste Management Plan calls upon the major producers of waste (CEA, EDF, AREVA), as well as ANDRA, to draw up a report on activities planned or already in hand, and to assess the options for using finished products based on recycled steel in nuclear installations. This is the goal of the inter-operator working group.

For its part, AREVA has launched studies and analyses of waste management practices implemented by companies located in countries that have industrial recycling facilities not specific to the nuclear industry. A comparative study of the environmental impact of the facilities for managing very low-level metallic waste, from landfill to recycling and taking in intermediate scenarios involving decontamination or recycling within the nuclear industry, has been carried out on categories of waste that do not carry a significant or quantifiable risk of exposure to radioactivity, always at levels well below the regulatory thresholds. The outcome of this study supported the recycling approach, driven especially by the need to save raw materials.

Avoiding liabilities

Nuclear plants that have definitively ceased to operate are covered by programmes to prepare for final shutdown (PAMAD/OPMAD), and to clean out and decommission the associated equipment. All these operations are designed to guarantee the intrinsic safety of the structures and equipment to be left in place, and to prevent any environmental impact. They are carried out in accordance with new safety standards, reflecting the risks arising from decommissioning activities. The applications for authorization to implement these measures are reviewed by IRSN and authorized by the ASN, in the same way as requests for operating licenses.

The safety standards applicable to decommissioning operations require a review of the waste study. In fact, the waste generated by decommissioning is of a different character and a volume often far greater than that generated during operation; it affects different areas of work and is handled under different conditions. The management of this waste needs to be considered in the design of the installations, and should also be the object of financial provisions raised in accordance with Article 8 of the Decree on "Procedures" (2007-1557 of 2 November 2007).

An AREVA guide on this subject is now being drawn up, based on the work of a multi-disciplinary group bringing together specialists from different parts of nuclear industry (operations, engineering, safety, waste management, eco-design, decommissioning). The environmental and waste management aspects, and the exposure of workers to ionizing radiation, are attracting particular attention.

Management of waste from decommissioning

Radioactive waste is defined as any waste from nuclear waste zones (ZDNs). However, some areas are classified as ZDNs for the sake of simplifying operating activities, or for the sake of precaution. The waste in these areas may never have been contaminated by any radioactive elements. These practices are all the more punitive as there is no threshold in France below which waste may be classed as conventional. Hence, its classification as radioactive waste may be simply due to its "geographical" origin. The impact of these practices may be considerable when it comes to the quantities of nuclear waste produced (with all the technological and economic implications), particularly when installations come to be decommissioned.

Department D3SE has set up a multi-disciplinary working group (engineering, eco-design, operation, radiation protection, waste management, decommissioning) whose aim is to identify and promote the best practices and methodologies to reduce the impact of decommissioning nuclear installations, particularly:
– the environmental impact;
– the impact relating to the general and radiation protection of workers;
– the social impact;
– the economic impact.

It should lead to the production of a document to be applied by the entities involved in the design and operation (including maintenance) of nuclear installations.

Developments in waste management designed to reduce the environmental footprint

The efforts being made by nuclear sites to update their inventories and to classify radioactive waste help to adapt and optimize their management programmes. As a result, the volumes of operational waste in storage and the quantities of waste without a specific route have been substantially reduced. Legacy waste is also included in these programmes, with significant amounts of historical waste (especially very low-level waste) removed from storage.

Early consideration of the future of the plants after they cease operation, and the practical and conceptual developments in waste zoning, help to reduce the future impact of radioactive waste. These changes in the method of management are generally based on the concept of radiological cleanliness, which ensures that part of the waste remains non-radioactive. We could therefore envisage treating or recycling a larger proportion of the waste from nuclear operations into more generic routes. ■

LONG-TERM MANAGEMENT OF RADIOACTIVE WASTE

Management of long-lived radioactive waste: challenges and actions by the ASN

by Géraldine Dandrieux, assistant to the Director for Waste, Research Installations and the Nuclear Cycle – French Nuclear Safety Authority (ASN)

To fulfil its mission to monitor safety and radiation protection, and more specifically to provide for safe and sustainable management of radioactive waste, the ASN applies various levers:
– defining the legislative and regulatory framework;
– drawing up recommendations and instructions for sustainable management by way of the National Radioactive Material and Waste Management Plan (PNGMDR), which it edits jointly with the Directorate-General for Energy and Climate (DGEC) at the Ministry for Ecology, with the assistance of the PNGMDR working group;
– monitoring, inspecting and reviewing safety files to verify the safety of the storage conditions for waste, the proper implementation of the conditions defined for the production of packages of long-lived intermediate and high-level waste, and compliance with the instructions applicable to the management of radioactive waste. Particularly by drawing up reports to the government on the two projects for disposing of long-lived waste (the "deep geological disposal" project and the project to dispose of LL-LLW), the ASN seeks to verify that the conditions in which these projects are carried out ensure the long-term and operational safety of the management of this waste;
– an investment at the international level in the exchange and promotion of best practice in the management of radioactive waste.

Long-lived radioactive waste

Radioactive waste is defined by the "Law on the sustainable management of radioactive materials and waste" as radioactive substances for which no subsequent use is planned or envisaged.

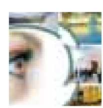
The French classification of radioactive waste groups it according to two main characteristics, the level of radioactivity of the radioactive elements contained in the waste, and their half-lives. For "long-lived" radioactive waste, this classification defines the following principal categories:
– long-lived high-level waste (LL-HLW), mainly made up of vitrified waste from spent fuel after reprocessing. These packages of waste concentrate most of the radionuclides, both fission products and minor actinides. The level of radioactivity of this waste is of the order of several billion Bq per gram;
– long-lived intermediate level waste (LL-ILW). This waste comes mainly from the reprocessing of spent fuel and from maintenance and operation activities in the treatment plants for this fuel. This is referred to as structural waste: the hulls and end-pieces that constitute the sheath containing the nuclear fuel, technological waste (used tools and equipment, etc.), and waste from the treatment of effluents such as sludge. This waste is placed in cement-sealed packages, compacted or bituminized depending on the type of waste. The level of radioactivity of this waste is of the order of one million to one billion Bq per gram. Long-lived intermediate and high-level waste is earmarked for disposal in the geological repository currently being investigated by ANDRA in accordance with the Act of 2006;
– long-lived low-level waste (LL-LLW). This category is made up mainly of graphite and radium waste. Graphite waste, originating mainly from the decommissioning of reactors of the uranium graphite natural gas type (the first generation of reactors in France). It contains a level of radioactivity of the order of ten to one hundred thousand Bq per gram. Radium waste, mostly from non-nuclear industrial processes (such as the processing of minerals containing rare earth elements), is mainly made up of long-lived alpha-emitting radionuclides, and has a level of radioactivity from a few dozen to a few thousand Bq per gram. Long-lived low-level waste is earmarked for disposal in a shallow underground facility under analysis by ANDRA in accordance with the Act of 2006.

Apart from the radioactivity that it may contain, this waste poses a specific challenge arising from the half-lives of the radionuclides that it contains. The main challenge involved in the long-term management of this waste is to be able to isolate and contain these radionuclides for as long as possible. The research efforts called for by the Act of 2006 into the separation and transmutation of actinides are also intended to reduce their harmful effects.

Amendments to the legislative and regulatory framework to provide a new basis for managing radioactive waste at the production sites and on the storage facilities and repositories for radioactive waste

The ASN helps to draw up regulations covering the management of radioactive waste. In this area, the ASN was one of the main stakeholders involved in drafting the Act of 2006, a reference document that lays down the main principles for the sustainable management of radioactive materials and waste, and particularly the objectives relating to various aspects of managing long-lived radioactive waste:
– for long-lived high and intermediate-level waste, it defines the framework within which a system of reversible deep disposal should be developed, along with the research to be conducted into separation and transmutation to reduce the harmful effects of this waste;
– for long-lived low-level waste, it proposes solutions for disposing of graphite and radium waste.

Since the promulgation of the "TSN" Law on transparency and safety in nuclear matters (Law No 2006-686 of 13 June 2006), which established the ASN as an independent authority, the ASN has been involved in a process of updating the regulations that apply to nuclear installations. More specifically, in



Compacted LL-ILW waste packages in CSD-C (standard containers of compacted waste) of spent fuel from AREVA's plant in La Hague

connection with recasting the general regulations applicable to these installations, the ASN has focused especially on strengthening the regulatory position regarding solutions to the management of radioactive waste. For example the draft Decree defining the general rules applicable to nuclear installations (the "INB Decree") sets out specific provisions to be reflected in the decisions taken by the ASN on the following points:
– storage of radioactive waste; special attention to be paid to monitoring and recovering waste being held pending disposal;
– packaging of radioactive waste: the decision currently at the draft stage makes the production of packages of radioactive waste bound for a repository subject to agreement by the ASN in every case (for long-lived low, intermediate and high-level waste). When it submits its comments on a solution for packaging the waste, the ASN will check with ANDRA, in accordance with the provisions of the Act of 2006, that the packages of waste for dispatch to the repository are acceptable. Such provisions are already applied to the waste packages of produced by the installations at La Hague;
– disposal of radioactive waste: a decision by the ASN will reflect the objectives relating to the safe disposal of radioactive waste, particularly in the long term, the methods of operation and monitoring of the repositories to guarantee safety both during operation and after the transition to the monitoring phase for these repositories. This decision will enable a regulatory level to be defined in addition to the guides published by the ASN on the disposal of radioactive waste in deep geological formations (for the disposal of long-lived intermediate and high-level waste) and the general guide to safety when selecting a site for disposing of long-lived low-level waste.

The ASN plans to finalize these regulatory texts by the end of 2012, particularly to meet the requirements to transpose the reference levels established by the Western European Nuclear Regulators' Association (WENRA). These texts will be published on the ASN web site for consultation with the various parties involved.

Drawing up recommendations and instructions for the sustainable management of long-lived waste via the PNGMDR

The Act of 28 June 2006 defines the objectives of the National Radioactive Material and Waste Management Plan (PNGMDR) and the framework for its creation. The ASN manages the production of the PNGMDR jointly with the DGEC. The publication of this Plan in the form of a Decree enables the work priorities defined by the Law to be specified more precisely. The PNGMDR and its associate Decree are tools that help to plan in more detail the actions to be put in place in order to guarantee safe management of long-lived waste in particular.

For example, the draft PNGMDR for 2010-2012 defines, for long-lived waste:
– the objectives against which the disposal of long-lived low-level waste should be studied: the handling of graphite and process waste from the decommissioning of uranium graphite natural gas and experimental reactors, radium waste that cannot be disposed of on the surface, and other types of LL-LLW. ANDRA is also called upon to submit a study before 31 December 2012 into ways of handling other types of waste, particularly some bituminous effluents, and to look into the possibility of managing graphite and radium waste separately;
– for long-lived high and intermediate-level waste, the draft PNGMDR Decree stipulates that:
  • the CEA should coordinate research into the separation and transmutation of long-lived radioactive elements, in order to submit a report on this research in 2012;
  • producers of long-lived intermediate-level waste are carrying out studies on recognizing and packaging this waste in order to provide methods of packaging conducive to the operational and long-term safety of the sites belonging to the producers and managers of this waste;
  • the waste producers present regular progress reports on the studies being carried out in order to package all the LL-ILW produced before 2015 by 2030.

Inspection and monitoring of safety in the management of long-lived radioactive waste

1. Monitoring the safety of waste storage

Pending the implementation of solutions for the final management of the waste, the ASN needs to ensure that *ad hoc* measures are taken by the operators to guarantee the safety of the storage facilities for long-lived waste.
The challenges are then to:
– verify the safety of the existing installations, particularly by way of renewed safety inspections;
– oblige the operators to recover and package the oldest waste for interim storage in more recent installations;
– to ensure that new installations for storing waste are planned and constructed, in order to take both new waste and re-packaged waste from old installations.

a. Verifying the safety of existing installations and ensuring that legacy waste in these installations is recovered

As stipulated in the regulations (particularly the Decree of 2 November 2007), operators have to review the safety of their installations every 10 years. In the course of these safety reviews, the operator should verify that his installation complies with the applicable regulations, carry out any necessary renovation and improvements to allow the installation to be operated in accordance with the regulations up to the next review.

When the ASN finds that an operator has not always met his commitments to recover his legacy waste and that, as a result, some storage facilities do not deliver optimum safety levels, it asks the operators to enhance the monitoring procedures at these installations or to take constructive steps to improve the level of safety and to commit to the deadlines for recovering the waste contained in these installations in accordance with the demands of safety. This is the case, for example, for some legacy LL-ILW from La Hague, graphite waste from EDF (for example, EDF has constructed a geo-technical barrier around the silos at INB 74).

b. Providing new waste storage facilities

In parallel with the work being carried out to maintain the safety of the existing installations, the ASN believes that, given their age, some installations should have any stored material removed before being decommissioned. Disposal routes need to be found for the waste from these installations pending the commissioning of the deep disposal repository. New installations also need to be commissioned.

When reviewing applications for authorization to establish these installations, the ASN not only verifies the safe design of the installations but also checks that the installation has the capacity to handle the existing waste at the nuclear plants and the waste to be produced in the future, so that all this waste will meet with storage solutions pending the availability of long-term disposal facilities.

To this end, the ASN periodically analyzes the strategies for managing radioactive waste deployed by the major nuclear operators CEA, AREVA and EDF. Between now and 2011, for example, the ASN will comment on the CEA's strategy for managing radioactive waste. The big issue for the ASN is to ensure that a coherent set of actions and resources (existing and planned installations) put in place by the CEA to provide for safe management in the medium term (up to 10 years and beyond) of all its radioactive waste, particularly any waste that has no specific route today.

2. Packaging of long-lived intermediate and high-level waste

Under the operating licenses for plants UP2-400 and UP3, the ASN grants permits for the production of new packages manufactured in these plants at La Hague. In so doing, the ASN approves not only the safety of the manufacturing process but also the package of waste that is produced. It is important that the packages of waste produced now in preparation for their future disposal should meet certain performance and quality criteria, particularly with regard to long-term safety issues, i.e. after the closure of the repository. For example, the containment capability of the matrix enclosing the waste, and its resistance to lixiviation, need to be studied and proven.

It is also important to check the effectiveness of the manufacturing process for the packages of waste and the organizational arrangements to guarantee that the production quality is maintained over time.

These monitoring measures, already implemented by the ASN for packages of long-lived waste produced in the UP2-400 and UP3 plants are the subject of a draft decision by the ASN concerning the packaging of the waste and the acceptance of the packages at the repositories. This decision has been published for consultation purposes on the ASN web site since last September.

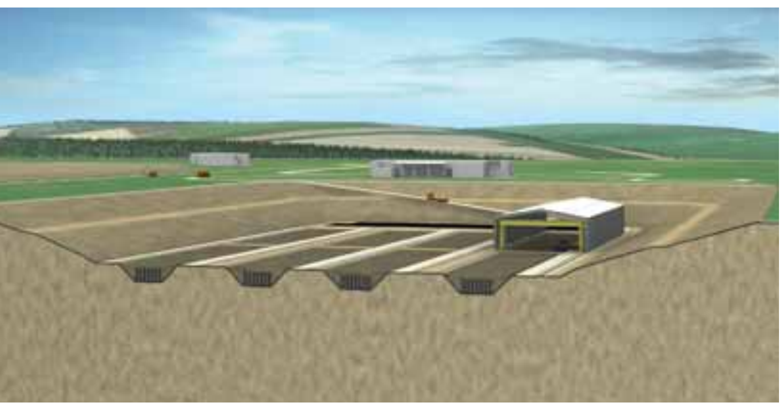
With regard to long-lived intermediate-level waste, it is important for safety reasons that the legacy long-lived intermediate-level waste should be recovered from the installations where it is currently stored in order to be packaged. To this end, the waste producers need to develop and implement packaging solutions to facilitate the safe long-term management of this waste and to optimize the safety of their storage facilities pending disposal. The PNGMDR addresses these concerns by calling upon the producers of this waste to report on their progress in recovering the legacy long-lived intermediate-level waste, and also to look into new alternative processes that provide a higher degree of safety, particularly in long-term disposal.

Anticipating the development of safe solutions for long-term management: technical review of the intermediate stages in the development of repositories

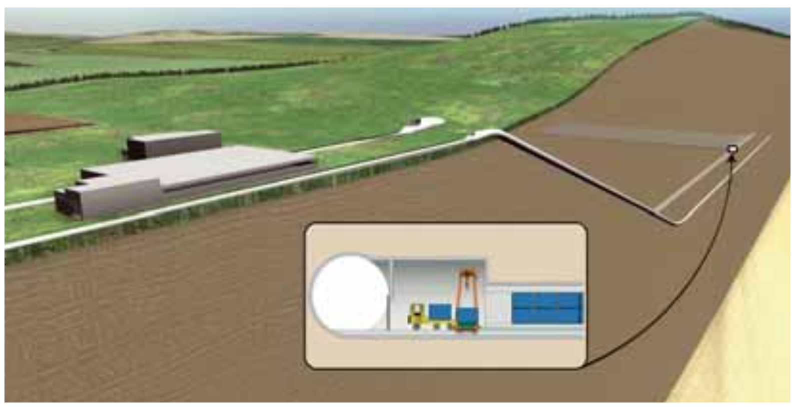
1. The deep geological disposal repository

Since the launch of the project to dispose of long-lived intermediate and high-level waste, the ASN has reviewed the various files produced by ANDRA over the years. These files

Repository projects for LL-LLW (radium and graphite waste)



Presentation of a disposal solution under a modified covering



Presentation of a disposal solution under a solid covering

Linking gallery at the Meuse/Haute-Marne underground laboratory

covered the review of the permit to run the Bore laboratory, the file referred to as "2001", in which ANDRA presented the initial elements of a feasibility study for a deep disposal repository. At this time, the permanent group on long-term disposal facilities for radioactive waste looked into the safety procedures developed by ANDRA, the methodological tools used to prove the safety of any disposal (modeling tools, scenarios to be considered in assessing safety, etc.) and their compliance with the objectives set out in the fundamental safety rule in force at the time, RFSIII.2.f. Expert opinions were also produced on the files relating to the migration of radionuclides and the mechanical behavior of a repository in this type of environment. The "2005" file was a second major milestone in the review of the feasibility of a deep disposal repository carried out by the ASN. This study was intended to show the feasibility of a geological repository in clay formations. The conclusions of the IRSN, which commented on the study, showed that such an installation was "feasible" in the so-called transposition zone where ANDRA had carried out geological investigations to validate the geological properties of the rock. When this study was completed, the ASN asked ANDRA to proceed with the planning work by examining a number of issues in more depth.

The Act of 2006 on the sustainable management of radioactive materials and waste provided a new framework for reviewing the study into deep disposal, particularly by laying down the principle of reversible geological disposal and by defining a calendar for reviewing the application to create this facility. In accordance with the Law, ANDRA submitted several applications in 2009. The first concerned the restricted area of interest for in-depth investigation ("ZIRA"), aimed at reducing the scope of the so-called transposition zone and using supplementary studies to confirm the favorable nature of the geology at the site for the potential installation of a repository. At the beginning of 2010, the ASN provided the government with a favorable opinion on the ZIRA put forward by ANDRA, while recommending further investigation to refine the data obtained.

As stipulated by law, the other papers submitted by ANDRA concern the options for safety, reversibility and design chosen for disposal, the scoping document covering the nature of the waste to be considered for disposal, and some storage solutions to enable the waste to be managed pending disposal. These elements were the object of a study carried out by a standing committee at the end of October 2010, particularly concerning the safety guide for the geological repository drawn up by the ASN in 2008 to replace RFSIII.2.f.

The ASN has commented on this file and submitted requests to ANDRA for the agency to expand its safety case in the light of the application for the establishment of the installation in 2014 and more specifically for the interim meeting scheduled for 2012.

2. The long-lived low-level waste repository

In mid-June 2008, in accordance with the provisions of the Act of 28 June 2006, ANDRA launched a call for tenders to identify a site suitable for shallow disposal of mainly graphite and radium waste (there is other long-lived low-level waste including old radioactive objects for "domestic" use and spent sealed sources like lightning conductors and fire detectors, along with some bituminous waste). At the end of the selection process, and after receiving the comments from the ASN and CNE on the analysis carried out by ANDRA into the potential sites, the government announced the selection of two locations in June 2009. As the chosen municipalities decided to dispense with the geological investigations that formed the next stage in the process, the government lifted the planning constraints defined by the law and asked ANDRA to hold discussions with the regions where some municipalities had entered bids in 2008.

It also asked ANDRA to examine the options for separate management of radium and graphite waste.

A working group of the High Commission for Transparency and Information on Nuclear Safety, on which the ASN is represented, has been tasked with looking into the process of consultation to be established for the next consultation.

At the beginning of 2009, the ASN had expressed support for the selection criteria defined by ANDRA. The ASN notes that the unavailability of a site to dispose of long-lived low-level waste is liable to affect the safety of the processes to manage this waste, particularly the graphite waste currently stored at the installation of the operators. The ASN has therefore asked EDF to assist if necessary in decommissioning the graphite-gas reactors with an interim storage programme for graphite waste.

The PNGMDR for 2010-2012 calls upon ANDRA to continue with the studies into the inventory, knowledge, treatment and packaging of long-lived low-level waste for a new technical proposal to be submitted in 2012.

International investment to promote best practices in the management of radioactive waste

The ASN devotes almost 5% of its activity units to actions at the international level. When it comes to managing long-lived radioactive waste, it is essential for an authority like the ASN to consult with those of its international counterparts that are furthest advanced in developing disposal facilities (such as the Swedish and Finnish authorities, with which it meets every year on this matter), and to work within international organizations and European discussion groups to promote its approach to safety.

Hence, the ASN is involved in the IAEA both to validate the international standards produced on this subject and to work on projects like GEOSAF (intended to assist safety authorities in evaluating safety case for geological disposal). The ASN is also represented within the AEN.

Moreover, within the regulators' group WENRA, whose job is to define common regulatory standards in Europe, the ASN is especially involved in drawing up benchmarks for disposal, having offered to take the lead on this proposal. As part of its close involvement in sharing ideas at the European level on deep storage, the ASN led the "European Pilot Group" in 2009 and 2010, tasked with finalizing the expert report on assessing a safety case prior to authorizing the establishment and operation of a deep disposal facility. This work has been done in collaboration with experts from the Belgian, Swedish, Finnish, British, Italian, Spanish and Swiss safety authorities and from international organizations (IAEA, NEA, EU). ■

Optimizing the routes for managing radioactive waste: a challenge for the future

by Fabrice Boissier, head of Risk Management – French National Agency for Radioactive Waste Management (ANDRA)

Thanks to a policy for managing radioactive waste applied in France for many years, 90 % of the volume of radioactive waste produced in France has an operational disposal route. For the remaining 10 %, the routes are at the proposal or the study stage. While this situation is satisfactory overall, we must not forget that managing this waste represents a burden on society – in the economic cost of this management, in the difficulty of finding sites to establish repositories, and in the radiological impact of the treatment and disposal sites, even though this is kept to a very low level.

It is then essential to look into ways of improving this management; to optimize the waste management routes, having first identified the parameters that need to be optimized. This is one of the tasks laid down in the National Radioactive Material and Waste Management Plan (PNGMDR) for 2010-2012, in a working group headed by the Ministry for Ecology, Sustainable Development, Transport and Housing.

This article presents the views of ANDRA on this issue, focusing especially on the way in which optimizing the routes can contribute to discussions on the establishment of disposal facilities for long-lived low-level waste, currently at the study stage.

Some definitions

By a "route", we mean the whole management chain for a type of waste, from production to disposal. This involves several stages, which may or may not apply depending on the type of waste, with some intermediate stages repeated in some cases. It starts at the time the waste is produced, possibly with some initial sorting. Then there may be some treatment of the waste (possibly after transfer to a dedicated centre), and packaging in order for the waste to be disposed of safely. Finally, the package may be disposed of in an appropriate repository, sometimes after a more or less lengthy period of storage, according to the availability of the disposal route. The storage may also be at an installation set up for this purpose.

By way of illustration, the next page shows a schematic representation of the management chain specified by the PNGMDR.

Each of these stages entails constraints, costs and possible impacts which then need to be taken into account if we wish to optimize the whole route.

But what exactly do we mean by "optimization"? This assumes that we have first defined the objectives that we seek to achieve.

These may include reducing the risks, limiting the consumption of disposal volume, reducing costs, etc.

The overall objectives to be considered fall within the legislative and regulatory framework: top of the list is the protection of people and the environment, an objective set out in the Environmental Code in particular. Article 3 of the Decree of 16 April 2008, which sets out the provisions for the PNGMDR, mentions other objectives to be addressed:

"1. The coherence of the system for managing radioactive waste should be analyzed, along with its technical and economic optimization;

2. The repositories for radioactive waste, few in number and of limited capacity, should be used as efficiently as possible by the different stakeholders;

3. The routes for managing radioactive waste should take account of the volumes of waste transported and the distances to be covered between the storage and disposal locations."

Land use planning and the public acceptability of the methods used are further objectives to be taken onto account.

Of course, these general objectives then need to be broken down into operational criteria to enable the options to be assessed (radiation protection for workers, long-term safety, cost per m^3, etc.).

The optimization process

Work on the inventory of waste

The first stage proposed for optimizing the management routes is to focus on the inventory of waste. Among the waste listed in the national inventory drawn up by ANDRA, we can indeed identify several types of waste: for some, their management and final destination are not at issue, given the existing routes: these mainly comprise the large-scale waste received at the VLLW and SL-LILW repositories run by ANDRA in the Aube.

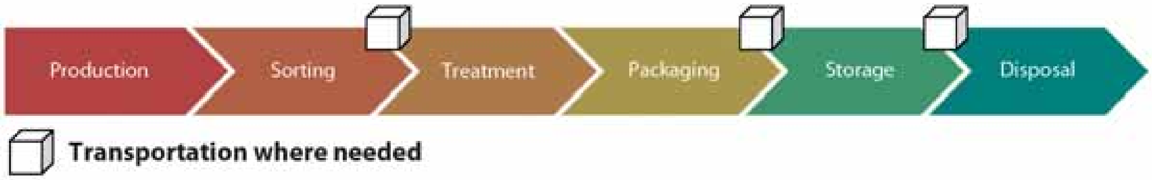
Other types of waste are allocated to a route, but this still has to be confirmed or optimized, because of uncertainties about the proof of safety, for example, because there is great potential for optimization at one or more of the treatment, packaging, storage or transport stages, or because of the current lack of a disposal site (as with LL-LLW).

Finally, a small number of them do not currently have an identified management route, because of their specific physical or chemical properties. This waste requires specific types of treatment or packaging, which are not yet available. This type of waste is given particular attention in the PNGMDR 2010-2012.

These last two categories of waste will be the focus of optimization efforts concentrating, at least at first, on waste that when grouped with other similar waste makes up a sufficient volume to offer enough potential for optimization.

Study of the options at each stage in the management chain

For these selected types of waste, a critical analysis of the current method of management allows us to identify any scope for improvement. This analysis can be carried out for every stage in the route. This can start from the production of the waste:



Schematic representation of the management chain specified by the PNGMDR

for example, in the case of decommissioning, the degree of compaction of the waste (particularly by cutting up) has a bearing on the operational radiation levels at the sites. Another example: for some waste with a relatively wide range of radionuclides, improved sorting could help to reduce the proportion of waste that needs to go into the long-lived waste routes, which are the most expensive, by separating out the elements containing the most long-lived radionuclides. Similarly, we could envisage forms of treatment to modify the physical and chemical composition of the waste. More simply, we can reduce the volume of waste by compaction, which represents a significant saving in the disposal volumes used and the cost of disposing of the waste.

The packaging stage demands particular attention, as the type of package may vary according to the final disposal location. Gains can be made by standardizing the packaging, trying as far as possible to develop multi-purpose packaging for different types of waste, also suited to different repositories. The package of waste is another component with a major bearing in terms of safety and radiation protection. The design features can also improve these aspects.

Each stage may provide opportunities for optimization. Naturally, this work can only be done in collaboration between the stakeholders involved at different stages in the waste management process, as each of them has the technical expertise to handle on or more of these stages. This is why the working group established under the PNGMDR ought to be a particularly suitable vehicle to take this forward.

Incorporation of these options into scenarios

Once all the possibilities for optimization have been identified, we need to pick out those that seem the most promising and to incorporate them into more general scenarios. To this end, we establish relevant combinations of options to manage different types of waste, which then constitute a scenario to be evaluated.

This evaluation needs to take account of the implications of the scenario at various levels.

These are some of the questions that may be raised: If new procedures are proposed, what will they cost and can we achieve sufficient economies of scale? If the proposed change introduces a need for additional storage, or changes the industrial scenarios for one or more disposal facilities, what is the impact on the storage and disposal schedules? What is the safety performance like at each stage? The evaluation needs to take a step back and consider all the implications for the different management routes, including the knock-on effect on other installations or types of waste. It also needs to take account of the risks (industrial, social, etc.) of not being able to implement the scenario.

Based on this analysis, we can assess the merits of the proposed scenario against the initial criteria, and perhaps compare it against a reference scenario. This will enable us to discard or retain the optimization options under review. Finally, this process should be conducted in an iterative manner, in order to test various options and attempt to converge on what seems to constitute the most satisfactory architecture for the whole waste management system.

The LL-LLW project in the forefront of efforts to optimize the routes

The case of long-lived low-level waste (mainly radium and graphite waste from the plants belonging to the UNGG route) constitutes an ideal case-study for optimizing the routes. For, although optimization can enable some improvements in the management of waste bound for existing installations, this is particularly true where a route has not yet been established.

Several proposals for disposing of long-lived low-level waste have been produced to date, particularly disposal under a modified covering (SCR) or disposal under a solid covering (SCI). This uncertainty as to the exact type of disposal is of course on issue when managing waste that is likely to be directed this way: the lack of a final disposal route demands the provision of storage facilities for this waste pending the availability of the repository; also, it is difficult to decide upon the packaging of this waste before the disposal facility has been designed, which raises the risk of having to carry out costly re-packaging operations. But it is also an opportunity that we need to grasp without delay: the choices that remain to be made in the design of the disposal facility broaden the range of possibilities and hence the opportunities for optimization: instead of simply optimizing the treatment route for a given type of waste, we may be able to optimize both the treatment/packaging of the waste and the repository intended to receive it.

So the very practical question faced by ANDRA – and all the stakeholders involved in managing radioactive waste – is this: what disposal route for long-lived low-level waste is it appropriate to establish? Between a disposal facility with a safety performance suited to the most low-level waste (and with a low price-tag) on the one hand, which automatically routes some waste into deep disposal (with a high price-tag), and disposal under a solid covering, expensive but able to receive a much wider range of waste under satisfactory safety conditions on the other, the choice of solutions is very varied. The question is all the more sensitive as the volume of long-lived waste is relatively small (around 150,000 cubic metres). For example, the costs of LL-LL waste disposal are mainly fixed costs associated with the installation. The characteristics of the installation itself therefore have a major bearing on the economics of the route.

Aerial view of the SL-LILW (short-lived low and intermediate-level waste disposal facility (CSFMA)) at the Aube

If we wish to apply the method of optimization set out above, we could consider graphite waste, for example, which is the most radioactive of the LL-LL waste. A question that we need to ask ourselves is whether we can develop treatment processes for this waste. If this treatment results in a reduction in volume without changing the amount to be disposed of, the gain will be limited, as the fixed costs will remain high. If, on the other hand, a process allows the radionuclides that pose the greatest risks to safety to be separated out into a sufficiently concentrated residue, it might be worth examining a scenario in which these concentrated residues were allocated to the route for LL-IL waste, while the graphite, with a substantially reduced radionuclide content, could be managed in a route of its own. But at that point, we could reconsider the safety requirements for LL-LL waste disposal to adapt them to the new inventory of waste. In conclusion, we must look to achieve our benchmark objectives: to compare the safety performance of the whole route (treatment + disposal); to assess whether the savings made in the design of the LL-LL repository offset the additional costs of developing the treatment process and managing the extra LL-IL waste produced, etc.

These brief notes are of course just an outline of the approach, and its implementation is much more complex. The definition of appropriate treatment methods is a technical challenge in itself. But the potential gains for society justify pursuing this approach in a detailed manner.

Conclusion

Optimizing radioactive waste management routes is an opportunity to reduce the burden on society of tackling the risks and impact of this waste. This can only be done within a relatively performant framework, in which the waste is already managed in a satisfactory way, particularly in terms of safety. Optimization can then help to improve the technical and economic conditions for managing the waste at an equivalent level of safety or improving the safety performance of these routes.

As for the route for long-lived low-level waste, the fact that the repository able to receive this waste is only at the preliminary study stage provides an opportunity to add significant value to the optimization process. It is in this spirit that ANDRA hopes to meet the request made by the DGEC and ASN in the PNGMDR to present industrial scenarios for managing this waste by the end of 2012. ■

LONG-TERM MANAGEMENT OF RADIOACTIVE WASTE

The LL-HILW (long-lived high-and intermediate-level waste) disposal project: working toward building the Cigéo Industrial Centre for Geological Disposal

by Thibaud Labalette, programme director – French National Radioactive Waste Management Agency (ANDRA)

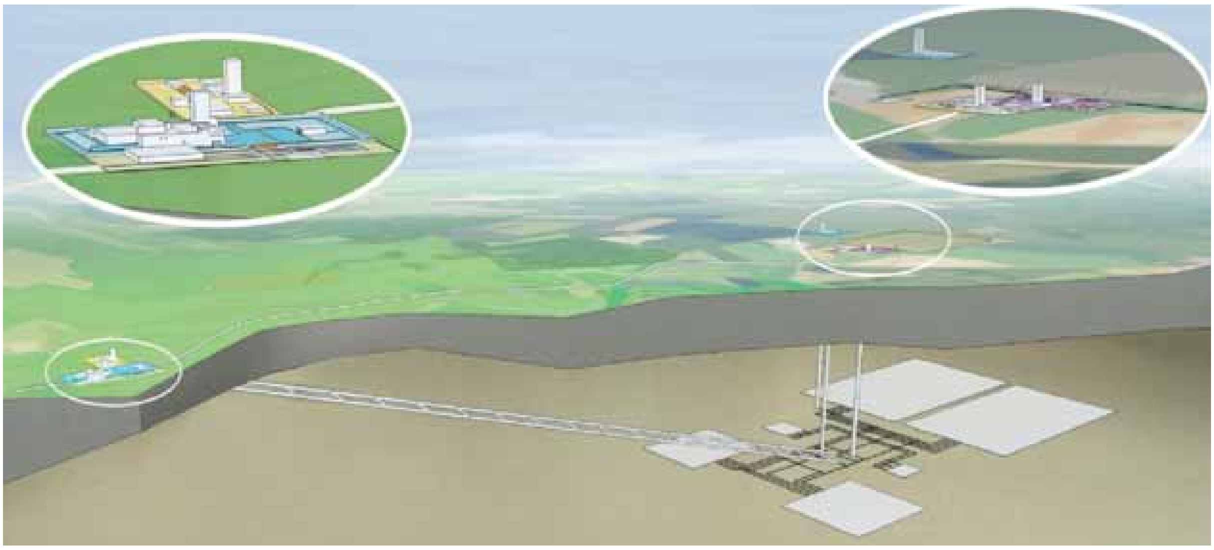


Figure 1: Illustration of a possible separation of some surface installations using an inclined drift (sample diagram of the repository after one hundred years of operation)

The Act of 28 June 2006 adopts reversible disposal in deep geological formations as the reference solution for the long-term management of high-level and intermediate-level long-lived radioactive waste. It also charges ANDRA with the task of continuing research and studies with a view to choosing a site for and designing a disposal facility so that the license application can be examined in 2015, and if granted, the disposal can be commissioned in 2025.

At the end of 2009, ANDRA submitted proposals to the French Government for the implementation and design of the Industrial Centre for Geological Disposal (CIGEO). An important milestone in the project was achieved when a potential site for the installation of underground disposal facilities was identified. After the site proposed by ANDRA was approved by the Government, detailed geological survey operations were carried out between May and July 2010. ANDRA is preparing to open up a new phase of dialogue with local players with a view to discussing surface facility installation scenarios. The selection of the implementation site will be validated after the public debate to be held during the second half of 2012.

The 2009 milestone also represents a new stage in the gradual process of designing a repository. Following the iterations of 1998, 2001 and 2005, which were mainly focused on the long-term safety of repositories, the 2009 dossier emphasizes the importance of operational safety which must take account of the atypical nature of an underground basic nuclear installation (BNI). It also includes the first results of the studies carried out in 2006 on the optimization of waste management solutions, which will be refined during the course of the programme. It provides the basis for defining the perimeters of the first operating phase of the repository in agreement with the waste producers.

Options for reversible disposal include proposals aimed at flexible and stepwise management of waste and the possibility of retrieving it. This means the approach to designing the repository must be geared towards reversibility. It also provides the basis for dialogue with stakeholders to prepare the public debate and the future law which will lay down the conditions for reversibility.

Repository project

Surface facilities (approximately 300 hectares) are comprised in particular of nuclear installations in which waste packages are received, inspected and packaged prior to storage, industrial facilities to support digging and maintenance work, administrative buildings, one or more dumping areas for excavated materials, approximately 40% of which will be reused for backfilling.

Underground disposal areas are designed in a modular manner so that it is possible to gradually build disposal cells and separate waste according to their properties. After an operational phase of one hundred years, the disposal cells will have been extended by about 15 km².

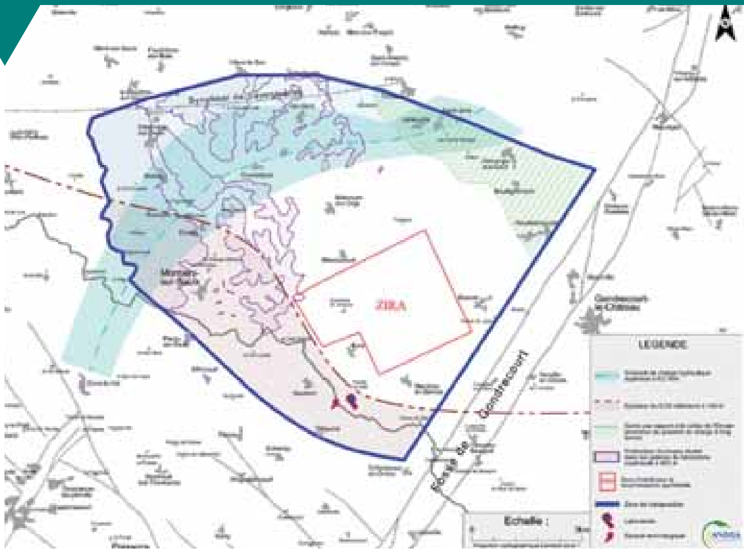


Figure 2 (left) – ZIRA (restricted area of interest for in-depth investigation): inclusion of geological and safety criteria
Figure 3 (right) - ZIRA (restricted area of interest for in-depth investigation): inclusion territorial settlement and local integration criteria

Surface-underground connecting structures are necessary to transport personnel, waste packages, materials, construction equipment and utilities such as ventilation systems Vertical shafts allow for materials to be transported during construction work. In order to provide more flexibility in selecting a site, ANDRA studied the possibility of using an inclined drift to transport the containers, which would make it possible to locate part of the surface facilities for the underground infrastructures at a distance of up to 5 km from the site (drift with a 10% slope).

Concerns regarding the repository site

The studies carried out by ANDRA until 2005 in its Meuse/Haute-Marne Underground Research Laboratory near Bure demonstrate the feasibility of a disposal facility in the Callovo-oxfordian clay formation. A 250 km² area was delineated around the laboratory where the characteristics of the clay formation are likely to be similar to those observed by the research laboratory.

In order to continue the studies and prepare a site proposal, it was necessary to delineate a smaller zone of interest for investigation of approximately 30 km² (an area twice as large as the area thought to be required for underground infrastructures after an operational phase of one hundred years). At the end of 2009, ANDRA proposed a restricted zone where underground installations could be hosted, pursuant to the Decree of 16 April 2008 which lays down the provisions for the National Plan for the Management of Radioactive Materials and Waste.

Following a reminder from the evaluators that the geological quality of the site must be a determining factor for selection, ANDRA undertook as exhaustive an investigation as possible into the geological criteria to be taken into account. ANDRA also initiated exchanges and innovative dialogue with local stakeholders to identify the territorial settlement and local integration criteria to be taken into account when selecting the disposal site, in addition to the geological and safety criteria as well as the industrial and environmental constraints.

On this basis, ANDRA proposed a "ZIRA" (zone of interest for deep geological investigation) to the Government at the end of 2009:
– located in the area identified as best fulfilling the geological and safety criteria (figure 2);
– compatible with the implementation of potential access to the drift in the bordering Meuse/Haute-Marne area and with the installation of main shaft accesses in a wooded area while avoiding installations in the urban areas of the towns (figure 3).

Industrial concerns

The Industrial Centre for Geological Disposal (CIGEO) will provide France with a safe, long-term solution for managing the radioactive waste produced by its nuclear power plants. At a global level, this will be the first repository of its kind in clay.

CIGEO will be a unique nuclear facility, built and operated for more than one hundred years. This long-term vision means that disposal structures will be gradually built as operation progresses.

In order to plan the first operational phase and the master plan for the development of the subsequent phases, it is necessary to plan the delivery of the different waste packages in close cooperation with the waste producers. The nature of the first packages delivered will determine the functions of the surface nuclear workshops which will be operated at the repository in 2025.

The industrial concerns also include the installations of waste producers. Depending on the choices made, they may need to develop complementary capacities for interim storage, removal from storage, packaging and transport if the current ones are insufficient (infrastructure and containers) at their own sites.

In 2009, ANDRA updated the inventory used to dimension disposal facilities to include nuclear power plants and nuclear research plants under construction (third generation Flamanville EPR reactor, ITER fusion reactor at Cadarache), waste related to decommissioning operations (dismantling), up-to-date forecasts of the cumulative tonnage of nuclear fuel from the reactors concerned and its type as well as new options for packaging certain types of waste.

ANDRA also proposed a first approach to disposal scenarios in 2009. By making better use of existing storage capacities while keeping the new capacities to be created to a minimum, the number of incoming waste packages could gradually increase when CIGEO operation begins. The centre's level of industrial activity could then be stabilized over the long term. Organizing disposal by separating the packages into different categories seems to be a viable solution to simplify operating conditions.

Figure 4 (left): Transfer by vehicle of packages in the SFR drift (SKB - Forsmark -Sweden)
Figure 5 (right): Remote control/command testing of a trolley in an underground gallery

Discussions are underway with producers to define these scenarios.

Safety and security concerns

While in principle, the operational safety of the centre is similar to that of existing BNIs, the atypical nature of the underground part of the centre makes it impossible to simply transpose practices; the underground environment is not easily accessible and therefore the underground facilities cannot handle nearly the same volume of nuclear activities as the surface installations. Management of co-activity between underground work and nuclear operations must keep the activities as separate as possible. No existing frame of reference in terms of fire risk management can be directly applied given the specific nature of the project.

The drift solution for the surface-underground link was subject to complementary studies, with regard in particular to its use for transporting disposal containers loaded inside transfer casks. Feasibility studies concerning a method of transport using a rail system (funicular) or using a self-propelled carrier were carried out, opening up alternative possibilities to the cask transfer in vertical shafts solution presented in the 2005 dossier.

ANDRA established a technical cooperation agreement with its Swedish counterpart, SKB, concerning research on drift solutions for surface to underground connection systems.

In accordance with the recommendations from the evaluators of the 2005 dossier, important steps were taken to reduce the risks involved in handling the waste packages (reliability of machines, lowering heights from which objects could fall, etc.). Options to simplify the ventilation of the usable part of the LL-ILW disposal cell were looked into; the design studied offers the possibility of installing a filtering unit on the air return duct of a disposal cell where necessary. The possibility of remotely controlling the equipment used underground for waste disposal via radio frequency was also looked into.

In accordance with the safety guidelines *"once the repository is closed, the protection of human health and of the environment must not rely on institutional monitoring and control which cannot be continued beyond a limited period of time"*. This implies a deep understanding of the evolution of the repository (state of knowledge/level of uncertainty) to ensure that the disposal is as reliable as possible when faced with internal events (failure of components) and external events (human intrusion, natural events) which are likely to occur in a period of time greater than one thousand years. For each amendment to the design, the subsequent impact on the performance of hydraulics and waste transport in particular is therefore considered.

The technical solutions studied while thinking ahead to the final closure of the repository serve as a basis for simulations and long-term safety analyses. However, this does not mean that the architecture of the repository is definitive; it may change during the iterative optimization procedure.

Reversibility concerns

The Act of 28 June 2006 stipulates that disposal should be reversible for a period of at least one hundred years as a precautionary measure, but does not go as far as specifying the conditions for reversal. These conditions will be laid down by a new law which will be voted on after ANDRA's authorization request has been assessed and before the license to create a repository can be delivered by the French Council of State decree after a public inquiry.

Discussions already held with the stakeholders have revealed several possible reasons for the reversibility requirement, such as the need to monitor the disposal procedure, to retain the option of implementing other management methods, to maintain the possibility of intervening in case of an abnormal event, to be able to retrieve packages if the waste were to become usable, as well as to not abandon the site.

In order to respond to these different expectations, ANDRA has proposed an approach to reversibility which relies on technical mechanisms aimed at simplifying the potential retrieval of waste packages and on a decision-making process to pilot the disposal procedure. To facilitate dialogue with French and foreign stakeholders, ANDRA has offered to define a reversibility scale. This scale illustrates the progressive nature of the disposal process and makes it possible to set forth decision-making milestones matching the passing of levels defined in the scale. The scale also shows that the "passive" nature of disposal safety increases as the disposal processes progress. This work is part of the Nuclear Energy Agency (NEA)'s *"Reversibility and Retrievability"* project, the results of which were presented during the international conference in Reims held on 14-17 December 2010.

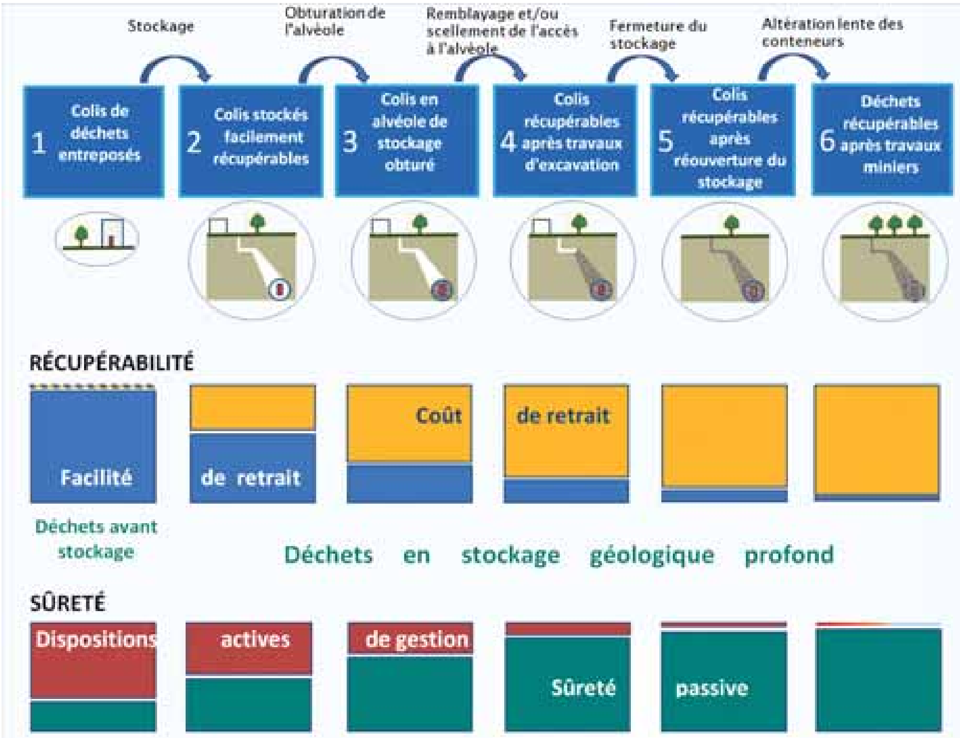


Figure 6: Evolution of the ease of retrieval and passiveness of the facility according to the level in the scale

Economic concerns

A global optimization approach was defined in 2006. A working group was formed between ANDRA and waste producers with a view to listing and defining a set of ways in which to optimize the project. The study of these different options was planned in ANDRA's research programmes.

The planning stipulated that the project would be developed over a series of phases, with the first phase taking place between 2006 and 2009. The available results were included in the 2009 dossier, for example the reduction in the number of underground galleries. With regard to the other options, the first phase of study focused on feasibility, without the level of certainty being high enough to allow it to be used as a reference in 2009; the options were mentioned as variants in the 2009 dossier. This is the case for example of the extension of high-level waste cells, which requires construction procedures to be developed at the underground laboratory. The use of a tunnel boring machine to excavate part of the underground works was also studied between 2006 and 2009, but it was not fully demonstrated to be a feasible option given the special geological conditions; a trial could be run at the laboratory to test this digging method.

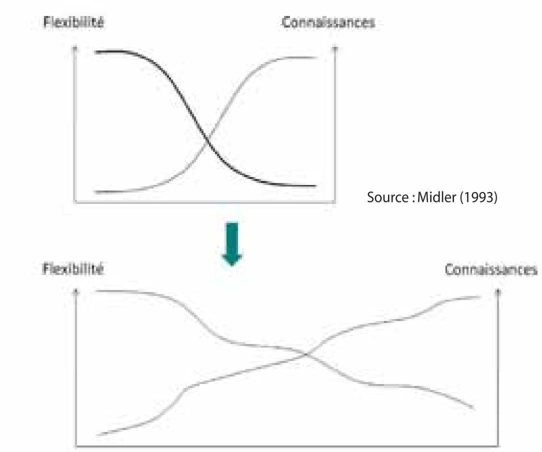


Figure 7: Reversibility in the interests of project optimization

Optimization of the design choices, which was initiated in 2006, will naturally be ongoing as the project develops. Studies carried out in 2010-2011 could mean that new amendments to the design may be included in the supporting documentation for the license application. The technical/economic optimization of the project will also be included in the specifications of the preliminary studies of the installations required for the industrial operation and the first operational phase of the repository.

It must always remain possible to make improvements once the license is granted, in view of the expectation of the period of operation exceeding one hundred years, the necessity to include experience acquired during the construction of the first disposal infrastructures as well as the time required to test various means of improvement. This need for flexibility will require regular meetings with the French Nuclear Safety Authority (ASN), during which safety standards will be re-examined.

Conclusion

The project is about to enter the definition phase for the CIGEO Industrial Centre for Geological Disposal. In order for it to be a success, it must respond to concerns related to local integration, industrial planning, safety and reversibility while keeping costs under control. ANDRA is responsible for striking the right balance between the various concerns.

The possibility of modifying waste disposal concepts over time and of leaving options open represents a major challenge for the project. As the CNE (French National Review Board) recommended in its June 2010 report: *"given that this is a unique facility for which the various technical possibilities are still being researched, the license application must reconcile the technical precision required by the administrative procedure and the flexibility needed to satisfy reversibility requirements and to take into account technical advances."*

This step-by-step approach provides an opportunity to optimize the project.

In a "conventional" project, carried out under time constraints, the designer eventually makes technical decisions by relying on the level of knowledge available to him at the time when those decisions must be made. The knowledge which is not available leads to contingency plans or gives rise to risks in the project. At the end of the project, the designer has acquired more knowledge but is only able to make minimal adjustments to the final product. This approach applies to the design of the first disposal facilities which will be built by 2025. ANDRA is applying proven methods for managing this project phase (for example the RG Aero 0040 standard), following the example of other significant programmes in the nuclear, aeronautics, space and arms industries.

In the case of the CIGEO project, disposal cells will be expanded over a long period of time, in the order of one hundred years, using a logic predicated on a succession of steps and having consulted several available options. The designer therefore acquires knowledge at each new phase of the project, in particular during the first phase, and this knowledge can then be carried into the following phase, with a view in particular to ensuring the continued optimization of the project. This process naturally forms part of the approach proposed by ANDRA 2009 file based on the principle of reversibility. ■

Recycling very low – level metal waste

by Michel Dutzer, Loic Tanguy, Alain Roulet, an article written collaboratively within the framework of the CEA, AREVA, EDF and ANDRA working group

Commissioning of the Morvilliers repository in 2003 made it easier to apply the regulations on the management of waste in basic nuclear installations, while satisfying the safety and economic requirements. The repository is designed to manage very low-level waste which is defined as waste which emanates from areas known for producing radioactive waste according to the Ministerial Ordinance of 31 December 1999 and which does not require the same packaging and monitoring measures as short-lived low and intermediate-level waste.

Therefore, given the principles applied to the establishment of waste zones, the level of radioactivity actually present for a significant proportion of the waste tonnage stored there remains only potential[1]: almost a third of the waste already stored in CSTFA (Morvilliers repository) has an activity concentration level lower than one Becquerel per gram. The logic of handling large quantities of metal nuclear waste there is something to consider, particularly for metal which has not been contaminated or which could be easily decontaminated. The forecasted flows represent approximately 50% of disposal capacities. Recycling this metal could save precious volumes of disposal capacity while fulfilling the objectives of sustainable development.

The recycling of nuclear waste was recommended in the 2010-2012 edition of the National Plan for the Management of Radioactive Materials and Waste. It acknowledged that initiatives had been taken in particular to recycle metal scrap resulting from the decommissioning of basic nuclear installations such as lead, copper and steel for reuse in the nuclear industry. It anticipates the creation of an inventory of measures taken or committed to by radioactive waste producers and ANDRA in terms of recycling by the end of 2011 and assesses, along with nuclear operators, the feasibility and opportunity of an industrial scheme for recycling metal scrap from dismantled nuclear plants in the industry in the years to come.

Recycling experience in France and abroad

Several countries already collect scrap metal waste for melting and partial recycling (Germany, Belgium, Finland, Italy, United Kingdom, Sweden, etc.).

In Germany, Siempelkamp has been operating a 3.2-ton capacity induction melting furnace in which over 24,000 tons of metal have been melted. It manufactures containers for radioactive waste and shielding devices. According to its level of radioactivity, some of the metal produced can be mixed with other sources of metal and used outside the nuclear industry in accordance with local legislation. Steel, copper and aluminum have been treated in the furnace.

Studsvik, in Sweden, also has an induction furnace with a 3-tonnes capacity in which over 20,000 tonnes of metal have been treated. The goal is to put the ingots back into the global recycling flow in accordance with the criteria of Swedish regulations (almost 90% of melted metal). This "release" is made possible by the level of radioactivity reached after melting; as a security precaution, recycled metal is diluted through the use of metal from other sources in a proportion of 1 to 10.

In France, the induction furnace at the Socodei/Centraco plant (4-tonnes capacity) has been melting low-level radioactive metal since 1999 (approximately 20,000 tonnes treated). This operation reduces the volume of waste to be disposed of (a tenfold reduction) as well as a "re-classification" from the "low-level" category to "very low-level" as a result of decontamination during the melting process. Part of the metal is reused as shielding on the inside of waste packages. Other uses are being explored.

Since 2003, the CEA has been operating a radioactive lead recycling facility in association with "conventional" industry players. In this type of recycling, the lead is first melted in the decontamination workshop in Marcoule (ADM) where the level of decontamination reached means it can be used to produce decontaminated material usable outside nuclear facilities and without any radiological risk. Detailed traceability of the material is ensured. The products of recycling include biological protection and shielded cells for the nuclear industry.

French context for recycling radioactive scrap metal

The transposition of waste mapping to very low-level scrap metal leads to research on routes which can guarantee traceability from transformation through to reuse. These materials cannot directly benefit from infrastructure used for conventional metal recycling as their release is not an option.

The forecasted amount of tonnage of scrap metal to be stored at the Morvilliers centre is estimated at approximately 400,000 tonnes over a period of 30 years, i.e., 13,000 per year. This is to be compared with the tonnage of ferrous waste collected each year in France, which amounts to between 10 and 15 million tonnes. A scale factor of 1,000 follows which will have a decisive effect on the economic conditions in which recycling operations for scrap metal from nuclear waste zones can take place.

In addition, very low-level scrap metal sites are heterogeneous in nature (copper, black or stainless steel, etc) but also contain very homogeneous groups. For example, the dismantling of the nuclear equipment at the Eurodif plant will produce approximately 130,000 tonnes of a single grade of steel. Each recycling

1. The Ministerial Ordinance of 31 December 1999 stipulates that basic nuclear installations must be mapped out with nuclear waste zones. Based on the design, operating methods and history of the facility, this zoning method distinguishes nuclear waste zones where there is a risk of activated or contaminated waste and conventional waste zones in which waste is not activated or contaminated. Nuclear waste has to be managed in dedicated channels with reinforced traceability, regardless of its level of radioactivity.

Aerial view of the surface centre for very low-level radioactive waste at Morvilliers in the Aube

route, including the treatment of contaminated metal, the manufacturing of parts and outlets is specific to the type of material to be recycled.

Moreover, the radioelements in scrap metal can have different chemical properties and therefore will have a different reaction during melting. In the case of steel, certain elements like cobalt 60 and nickel 63 (activation products) preferentially form a solution in the molten metal while other elements such as actinides, uranium and plutonium isotopes and strontium are mainly found in slag or in fly ash in the case of antimony and cesium.

At this stage, there are two main processing methods possible to recycle scrap metal for reuse in the nuclear industry:

• In line with what is being done today at Socodei, processing can be carried out in full within the nuclear industry. This ensures the traceability of the materials. This method is particularly suited to waste which has been contaminated by soluble radioelements in molten metal.

However, if forming operations are necessary (rolling, machining or welding for example), dedicated nuclear industry equipment will be required along with the appropriate skills. This could limit the range of possibilities for reusing the metal.

• On the other hand, for scrap metal which can be easily decontaminated by melting, the feasibility of forming or shaping it in dedicated or temporarily dedicated workshops in non-nuclear installations without radiological constraints can be looked into, based on what is being done for the recycling of lead. The level of traceability to be reached must, however, be assessed for the materials, discards and induced waste.

This solution is only applicable to certain types of contamination, such as contamination from plant processes upstream of the nuclear combustion cycle. It involves skills from the conventional metallurgical and mechanical industries.

As the logic of the traceability of nuclear waste would have it, recycled products would also be reused in basic nuclear installations in areas classified as "nuclear waste zones" in such a way as to avoid the transformation of areas which are naturally "conventional waste" zones into areas of "nuclear waste." Alternatively, the recycled products could even themselves become nuclear waste zones within conventional waste zones. This would also lead to a restriction in the potential reuse both in terms of quantity and quality, as there could be a high level of quality requirements for certain products to be reused (for example the metallurgical quality of cooling cycle components).

Areas of activity of the National Plan for the Management of Radioactive Materials and Waste

A working group which brings together EDF, CEA and AREVA and mobilizes specific skills (for example from SOCODEI) was created in 2007 to evaluate the possibilities for recycling within the specific context of French regulations. ANDRA started working with the group in 2008. The goal of the group meetings was to exchange technical information on different potential recycling projects and to identify the problems which could arise. It is of course this group which will assess the feasibility and the opportunities for the recycling of VLLW scrap metal within the framework of the National Plan for the Management of Radioactive Materials and Waste.

Investigating the outlets along the usage history will bring to light the benefits of recycling scrap metal. Given the restrictions mentioned above, components of repositories, for example waste packaging containers, could be an interesting outlet to look into by developing new packaging concepts if necessary. Other equipment for nuclear installations, or even construction materials such as reinforcement bars could become possibilities. This degree of reuse must match the level of availability of very low-level metal scrap in terms of quantity and quality. It is the quality aspect of the steel grade on the one hand, and the radioelements present on the other hand, which determines which industrial route can be used.

The impact of traceability requirements on the industrial route must be studied. For example where the materials have been shaped in a conventional workshop, what will be the status of the shavings, lubrication or cooling fluids which came into contact with the recycled metal?

Usage restrictions for recycled metal components must also be identified. For example, the use of recycled metal containers could, in some cases, mean that the transit or storage areas of these containers are classed as nuclear waste zones, which would ultimately have a negative effect on the volume of very low-level waste to be managed.

Therefore, discussions with ASN are necessary in order to write up a doctrine on these issues.

Recycling must be assessed in terms of its impact on the environment and health in comparison with the disposal option currently in place. The impact concerns in particular the dosimetric cost of the activities involved (cutting of parts, melting, shaping, storage, etc.) and should include, where necessary, a long-term dosimetric evaluation for stored waste. Issues relating to discards, induced waste and transport must also be studied.

Another important aspect is social acceptance of the recycling methods envisaged. In the present situation, recycling of materials is planned within the nuclear industry. However, if materials must temporarily transit through conventional industry, agents handling these materials must be given every guarantee that there is no radiological risk.

The setting up of a recycling network must also make economic sense. This can be assessed by comparing the cost of parts made from recycled metal with those made from "conventional" metal. Savings in terms of disposal and from extending the lifespan of repositories must also be taken into account. A genuine economic model must in fact be created. It will provide the basis on which decisions concerning recycling operations can be made by identifying the impact of technical and regulatory constraints on costs.

Conclusion

There is a consensus on the need to optimize the use of the capacities of radioactive waste repositories. In this regard, the disposal of very low-level or only potentially radioactive scrap metal is not in line with sustainable development policies. Recycling could offer great benefits. However, recycling operations must be carried out within a specific statutory framework which imposes restrictions on the possibilities for reuse and on the methods for making recycled parts. The working group composed of EDF, CEA, AREVA and ANDRA set itself the target of identifying the technical, regulatory, social and economic obstacles which affect the feasibility and viability of radioactive metal scrap recycling networks.

Public authorities have recognized the importance of this issue and have not only incorporated it into the work programme of the National Plan for the Management of Radioactive Materials and Waste but also signed an agreement in August 2010 with ANDRA as part of the "programme of investments for the future." Part of the 100 million euros allocated to ANDRA is to be used to support the development of recycling networks by promoting and supporting industrial initiatives, consulting with waste producers and with potential users of recycled products. Optimization of the use of repository capacities is a clearly stated objective. The criteria according to which beneficiaries will be selected also includes the technical value of the projects, the economic impact (employment, returns for the State, etc.), the business plan and the expected return on investment, as well as the domino effect or impact of structuring on the industrial system by involving several public and private partners in the projects. ■

LONG-TERM MANAGEMENT OF RADIOACTIVE WASTE

Storage of solid tritiated waste for which there is no management solution

by Claire Fromonot and Jacques Rancher, Military applications division, CEA in Bruyères-le-Châtel, Christophe Douche and Philippe Guetat, Military applications division, CEA in Valduc

National context

In France, radioactive waste containing tritium, a radioactive isotope of hydrogen, is produced by CEA as part of its research and development activities, for military applications in particular. This waste is currently stored after treatment and packaging at the sites in Valduc and Marcoule as there is no definitive disposal route. Moreover, industry players and medical and pharmaceutical research laboratories have used and continue to use tritium for different applications which have generated tritiated waste, of which a limited amount also remains without a disposal route. In addition, from 2020 the ITER reactor will also begin to generate tritiated waste and will become the main producer of this waste.

The treatment and disposal systems currently in place only handle the least tritiated waste. The CENTRACO plant can incinerate or melt very low-level waste containing tritium as well as ANDRA repositories, however highly restrictive acceptance criteria makes it almost impossible to use these routes for tritiated waste. This situation has occurred due to the properties of tritium and the history of the repository site in the Aube area.

In view of the absence of a disposal route for the majority of tritiated waste, the Act of 28 June 2006 on sustainable management of radioactive materials and waste, provided for "the development by 2008 of storage solutions for tritiated waste which will enable their level of radioactivity to be lowered before disposal in surface or subsurface repositories" as part of the implementation of a National Plan for the Management of Radioactive Materials and Waste (PNGMDR).

The Decree of 16 April 2008 which lays down the provisions for the PNGMDR stipulates the data to be provided and puts the CEA in charge of the studies.

Waste inventory

An exhaustive inventory of the waste already stored or which will be produced by 2060 was carried out. Currently this waste results from:
– the CEA's military activities: operational waste and future dismantling waste;
– the CEA's civil activities: waste originating from biology research and research reactors;
– diverse nuclear sources: waste produced by "small producers", medical research centres, hospitals using tritiated sources, National Defence.

At present, EDF and AREVA, nuclear power producers, do not have tritiated waste for which there is no management solution.

Over the next decade, the ITER reactor will become the primary contributor to the inventory, firstly during its operating phase and then during the dismantling phase starting in 2050.

The inventory of solid waste is shown in table 1.

There is also liquid and gaseous waste but the volumes are very small and will be treated and stabilized before storage.

Management methods for solid tritiated waste

The proposed solution relies on a decay-in-storage method in the installations to be built near the main production sites (Valduc, Marcoule and Cadarache) after treatment and packaging of the waste by the producers.

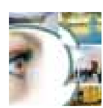
A storage period of fifty years will be necessary for each package. This length of time will make it possible to wait until ANDRA's future repositories are opened; their design will take into account the properties of tritiated waste at the end of storage. In addition, proven industrial technical solutions for waste packages exist for equivalent periods of time and are recognized by safety authorities. Finally, this length of time enables the level of tritium contained in waste to be reduced by approximately 16 times due to natural radioactive decay.

Given the large range of waste inventoried, it is necessary to classify them so as to propose solutions suitable for the inherent risks linked to each type of waste. This classification distinguishes waste containing tritium alone and waste also containing other radioelements; it also takes into account potential outlets depending on the residual level of radioactivity after the storage phase.

The types of waste were divided into six categories:
– very low-level tritiated radioactive waste, which is accepted by ANDRA's VLLW repository, except for tritiated waste;
– purely tritiated waste with outgassing lower than 1 GBq/year/drum;
– purely tritiated waste with outgassing greater than 1 GBq/year/drum;
– uranium waste with tritium, for which the management of alpha emitting radionuclides must also be taken into account in addition to tritium;
– irradiant tritiated waste with short-lived radionuclides for which biological protection is required to prevent any risk of exposure to radiation;
– irradiant tritiated waste with long-lived radionuclides which requires special storage solutions due to the irradiation from the packages.

In light of this diversity, it is necessary for the installations to be designed in a modular manner.

The packaging design for this waste relies on the knowledge of existing packages in order to guarantee sustainability over a period of fifty years.



The inventory of solid waste is shown in table 1.

	Stock status		Expected cumulative production until 2060	
Producers	Volume (m³)	Inventory (TBq)	Volume (m³)	Inventory (TBq)
CEA military applications	3,500	4,200	12,000	1,000
CEA civil applications	30	2	276	20
Diverse nuclear sources	50	220	120	20
ITER	0	0	17,000	33,000

In terms of the repositories, the level of tritium outgassing is a determining factor for the dimensioning of the facility in relation to the protection of workers and the public. It implies the use of ventilations appropriate to the level of risk which range from passive natural ventilation to forced filtered ventilation. For irradiant tritiated waste, the design of the installations is mainly dictated by the risk of external exposure to workers and the public.

Module for very low-level tritiated waste

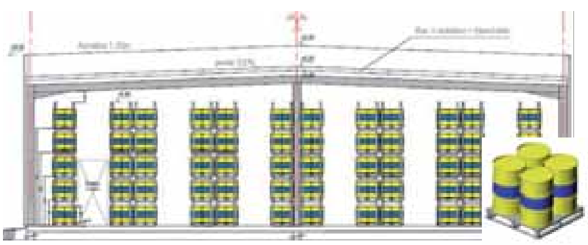
Waste is packaged in 1.3 m³ metal boxes. Each module will have a storage capacity of 1,000 packages, or 1,300 m³ of waste. The installations will be storage facilities with simple cladding not designed to withstand earthquakes and equipped with natural ventilation and classified as an installation for the protection of the environment (ICPE).

Module for tritiated waste with low outgassing

This waste is packaged in 200 litres drums which are guaranteed to be reliable for 50 years. They are stored in racks over 5 levels. Each module will have a storage capacity of 15,000 packages, or 3,000 m³ of waste. The installations will be storage facilities with simple cladding not designed to withstand earthquakes and equipped with natural ventilation.

These facilities will be classified as basic nuclear installations.

Two modules will be needed for the needs of CEA/DAM by 2050.



Module for tritiated waste with high outgassing

This waste is packaged in 200 litres drums which are guaranteed to be reliable for 50 years. They are stored in racks over 5 levels. Each module will have a storage capacity of 7,000 packages, or 1,400 m³ of waste. The installations will be storage facilities with simple cladding not designed to withstand earthquakes and equipped with a chimney fitted with a permanent surveillance system for tritium discharges with an extraction system which allows for sufficient air renewal.

These facilities will be classified as basic nuclear installations.

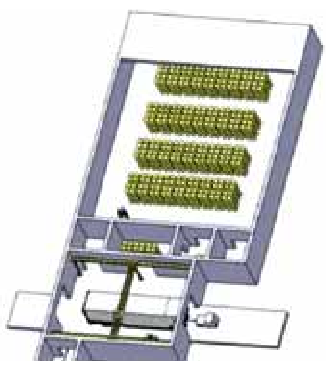
Two modules will be needed, one for the needs of CEA/DAM by 2025 and the other for the needs of the ITER reactor by 2050.

Module for uranium waste with tritium

This waste is packaged in 200 litres drums which are guaranteed to be reliable for 50 years. They are stored in racks over 3 levels. Each module will have a storage capacity of 1,000 drums, or 200 m³ of waste.

The building will be designed in order to withstand earthquakes and equipped with a ventilation system which guarantees a minimum degree of tritium tolerated in the building with a level of filtration adapted to the alpha risk and the outlet of which is equipped with a discharge surveillance system.

Only one installation will be necessary for the needs of CEA/DAM.



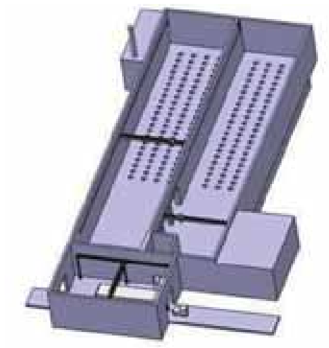
Module for short-lived radiating tritiated waste

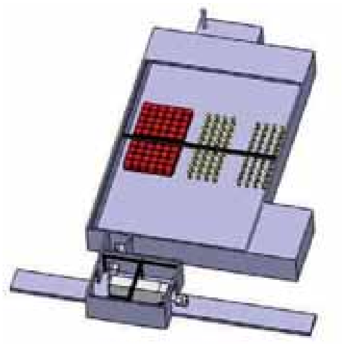
Waste will be packaged in a concrete container which can contain short-lived radioelements other than tritium. It will be stored across several levels depending on the type of package used (drums with reinforced concrete, CBF-C, CBF-K). The planned nominal capacity is 6,000 m³ of stored waste. The concrete, containing building will be designed for earthquake resistance. The ventilation system will be designed in order to maintain a minimum degree of tritium tolerated in the building with a level of filtration adapted for other contained radioelements. The outlet is equipped with a discharge monitoring system.

These installations will be classified as basic nuclear installations.

In the middle of the next decade, a module will be needed in Marcoule for CEA/DAM waste.

Two modules will be needed for the ITER reactor, the first for the operating phase and the second during dismantling.





Module for long-lived radiating tritiated waste

This type of waste must first be processed to reduce its level of tritium outgassing. It will then be packaged in sealed welded stainless steel containers suitable for ANDRA's future deep underground repository. Given the level of radioactivity and dose rate of the packages, storage in earthquake resistant, ventilated disposal cells is necessary. Detritiation of the cells may be considered if a leak is detected. Currently the planned capacity is 900 m^3 of stored waste. These installations will be classified as basic nuclear installations. By 2050, three modules will be needed for ITER during the dismantling phase.

In order to guarantee as little impact as possible, within reason, of the storage facilities on the environment, it is necessary for waste with the highest level of outgassing - purely tritiated waste or radiating tritiated waste - to be detritiated or packaged in gas-resistant containers due to the properties of tritium and its mobility before it is stored; this concerns in particular waste produced by the Valduc centre and by ITER.

The unavoidable residual discharge anticipated for all of the storage facilities will represent only a small fraction of tritium discharge in France (a few hundred TBq/year, i.e., less than 1g/year) and its impact on the environment and humans will be about one microsievert per year - one-thousandth less than the regulatory limit for the public which is one milliserviert per year.

The solution to store waste in close proximity to the main places of production or processing was adopted. It enables the transportation of large quantities of waste to be limited by avoiding rotations between production places and storage facilities.

This set of proposed solutions will enable waste producers to build the number and type of installations they require close to their production sites before final disposal. ■

Disposal of residue from uranium ore processing in France

by Philippe Crochon, Business Group Mines, Environmental and Social Responsibility division – AREVA NC

Between 1949 and 2001, 76,000 tonnes of uranium were produced in France from more than 200 mines in the Limousin region (40%), Pays de la Loire (20%) and the areas east of the Massif Central region (from Morvan to Forez, all the way to Cévennes) (20%).

Uranium ore was extracted from open-cast or underground mines of varying size according to the depth of the deposits. The extracted ore was then transported to one of the eight processing plants in the region where physical-chemical processing was carried out to produce a uranium concentrate called "yellow cake".

A distinction was made between two categories of ore products:
– low content ore (about 300 to 600 ppm – 0.03 to 0.06%) produced by static leaching. The ore was laid in stockpiles in sealed areas and sprayed with an acid solution. The uraniferous solution collected at the bottom of the piles was sent to the processing plant. At the end of the operation, processing residue was washed and stored. The yield was 50 to 80%.
– high average content ore (0.1 to 1% in French mines) were produced by dynamic leaching. After mechanical pre-treatment (crushing and grinding), the ore was subject to acid or alkaline chemical processing in order to obtain a soluble uranium solution. The liquid solutions containing uranium were then separated by filtering from the solid compound which formed the processing residue. The solutions containing uranium were transported to extraction and purification workshops. The uranium was ultimately processed to reach a solid form ("yellow cake" with a concentration of 750 kg/t). The yield was about 95%.

Residues from dynamic processing

Residues resemble clayey sand and have the same mineralogical composition as the original ore as well as various chemical precipitates. The residue contains residual uranium (approximately 5 to 10% of the ore's initial content) and all the radioactive daughters of U238 starting from TH 230 each with a radioactivity level equivalent to that of the ore (between 20 and 30 Bq/g). The radioactivity of the residue is approximately 75% of the initial ore.

It was stored in close proximity to the processing plants:
– either in former open-cast mines (with an additional dyke where needed to increase storage capacities);
– or in closed pools with an encircling dyke;
– or behind a dyke damming a thalweg.

The dykes were built using either the sandy residual compound from processing or with waste rock.

The storage areas can cover one to several tens of hectares and contain several thousand or million tonnes of residues.

Residues from static processing

The residue resembles rocky blocks of various size and contains a few tens or hundreds of ppm of uranium.

It is stored:
– either in stockpiles;
– or in open-cast mines;
– or is used as the first covering layer in dynamic residue repository sites.

All of this residue has a naturally low level of radioactivity and contains long-lived radionuclides.

In France, processing residues accounts for 50 million tonnes (31 million tonnes of dynamic residue and 18 tonnes of static residue) spread across 17 storage areas located in 13 French *départements*, most of which are regulated as installations classified on environmental protection grounds (ICPE, section 1735).

Rehabilitation of processing residues disposal sites

When mine works are stopped due to stocks running out or for economic reasons, the sites are rehabilitated. The main objective of this is to ensure long-term stability in terms of security and public health, to limit the residual impact as far as reasonably possible, to limit the surface area of land subject to usage restrictions and to succeed in integrating it into the landscape.

Due to the large quantities and tonnage, the residues were kept in the disposal sites. A solid, only slightly permeable covering was placed over the residues to provide a geomechanical and radiological protective barrier designed to minimize the risks of intrusion, erosion, dispersion of the products contained and the risks linked to exposure to the surrounding populations.

The layer was made using the materials available on the sites: static leaching residue was used for the first layer (which allowed the different categories of residue to be grouped together within the same disposal site in order to optimize its management) and waste rock for the second layer which forms favorable topography for draining meteoric water while taking into account future settling of the residue. A final layer of topsoil was laid down to allow revegetation of the site (limiting erosion and aiding integration into the landscape). Other materials are only used if the quality or quantity of the materials available on site are insufficient.

Before work begins, studies are carried out to improve knowledge of the sites (geology, hydrogeology, stability of infrastructure, etc), to test the efficiency of the materials chosen to cover the residues (petrographic and geotechnical nature, trial of

Former mining site at Bellezane (Haute-Vienne) before rehabilitation (1992)

Former mining site at Bellezane (Haute-Vienne) after rehabilitation (2001)

"test layers" on disposal sites to verify their means of installation, thickness, degree of compactness, role as a radiological barrier).

All the residue disposal sites are rehabilitated. Regular monitoring of the stability of the infrastructure, quality of the discharge and radiological exposure to surrounding populations is carried out at each site in accordance with the provisions of the Prefectoral Ordinance. The results are published on the website of the French National Network of Environmental Monitoring (RNM) which was launched at the beginning of 2010.

Measures taken by public authorities

With the closure of mining sites in the 90s, a set of measures was taken by public authorities which led to the publication of various documents, including:
– Barthélémy-Combes report (1993): objectives and technical conditions for rehabilitating residue disposal sites;
– Doctrine on the rehabilitation of disposal sites (DPPR 1999) accompanied by methodological documents on evaluating the stability of dykes (BRGM 2001) and evaluating the impact of disposal sites (IPSN 2001).

In addition, as part of the programme to lower the added effective dose for the public from 5 to 1 mSv/year, AREVA was asked to check compliance in 2000 and 2002 and to assess in 2002 the stability of the dykes.

We must also remember the MIMAUSA[1] (history and impact of uranium mines: summary and archives) programme implemented by the IRSN at the request of the DPPR (Directorate for the Prevention of Pollution and Risks) from 2003 which provides public authorities and the public with a compilation and synthesis of the data available for all the mining and residue disposal sites referenced.

We should also take note of the report published in 2005 by the working group of the radioprotection division of the CSHPF[2], which presented an overview of the situation of uranium mining sites in France.

There is one sheet for each disposal site in the inventory published by ANDRA.

National Plan for the Management of Radioactive Materials and Waste 1 (2006-2008)

Decree 2008-357 of 16 April 2008 which lays down the provisions for the PNGMDR (National Plan for the Management of Radioactive Materials and Waste) by implementing the 2006-739 Programme Act of 28 June 2006 on the sustainable management of radioactive materials and waste stipulates in article 10 on the disposal of residues from processing uranium ore, that a study be carried out on the long-term impact of the residues disposal sites on public health and the environment. This study includes:
– an assessment of the mechanical and geochemical behavior of the stored residues;
– an analysis of the long-term durability of disposal retaining dykes;
– a study of the long-term impact of residues disposal sites taking into account normal evolution and altered evolution scenarios.

These provisions are coherent with the extension of the studies requested previously, in particular with the application of the doctrine on the rehabilitation of disposal sites published by the DPPR in 1999.

The study carried out in the 1990s by AREVA on the geochemical classification of the residues shows that it has undergone significant diagenesis (sum of all processes by which sediment is converted into rock: compaction, dehydration, cementation, mineral changes) over a few years with the formation of new minerals (hydroxides, gypsum, clay) which influences the long-term behavior of radionuclides by reducing their mobility. By limiting water infiltration, the coverings help to maintain physical-chemical conditions which ensure this stability.

Studies related to the stability of the dykes have confirmed that these infrastructures are sound. For the site with a water covering, a project to replace it with a solid covering is under examination.

Analyses of the dosimetric impact assessment were carried out using analytical modeling taking into account the various transfer and exposure pathways which the surrounding populations may be exposed to in order to assess the added effective dose. In accordance with the DPPR doctrine, several scenarios were considered:

Former mining site at Bessines (Haute-Vienne) before rehabilitation (1978)

Former mining site at Bessines (Haute-Vienne) after rehabilitation (2010)

– a reference scenario corresponding to the current situation of the rehabilitated site;

– five highly unlikely altered evolution scenarios leading to a significantly deteriorated situation: loss of the covering, loss of knowledge regarding the site (housing built on the disposal site with or without covering, roadworks, playgrounds for children).

The results of the modeling of the nine selected sites shows compliance with the dose limit of 1 mSV/year in a normal evolution scenario and the potential dose, which would obviously be much higher for the altered scenarios, would be no more than a few tens of mSv/year.

National Plan for the Management of Radioactive Materials and Waste 2 (2010-2012)

While the results of these first studies form an important milestone in checking the safety of residues disposal sites in line with the approaches for other types of disposal, the PNGMDR for 2010-2012 requires additional studies to ensure the reliability of the first results. These studies involve:
– pursuing the physical-chemical classification of residues by integrating new data acquired from different disposal sites;
– defining the criteria to assess the long-term stability of retaining dykes taking into account the end to monitoring and maintenance;
– assessment of the results of modeling of the radiological impact in connection with the monitoring results and, where necessary, identification of areas to reinforce the quality of the coverings.

Studies of former mining sites are also required to investigate in particular the water processing methods used where needed to improve water quality, the studies carried out on new processing methods and on the impact of discharge on the quality of the sediment in receiving bodies of water. These studies will be supplemented by a dosimetric analysis of the impact of reusing waste rock in the public sphere.

Circular dated July 22 2009 from MEEDDM/ASN

Building on the actions already taken in relation to former uranium mines, the Ministry for Ecology, Energy, Sustainable Development and the Sea (MEEDDM) and ASN defined an action plan in a circular dated 22 July 2009 comprising the following four areas of work:
– controlling former mining sites;
– improving understanding of their impact on the environment and health and, if necessary, their monitoring;
– achieving a better understanding of the reuse of waste rock and reducing its impact if necessary;
– improving information and dialogue.

The action plan began with inspections of former sites, particularly those which have not been monitored for a long time due to administrative decisions; by assessments carried out every three years by the *départements* on mining sites (work history, results of site visits, verification of potential impacts on the environment, suggestions for improvement where needed), by a census of the waste rock reused in the public sphere by helicopter-borne spectrometry followed by a ground control of any radiometric abnormalities detected and finally by the creation of CLIS (Local information and oversight committees) by the Préfets of the *départements* where none currently exist (there are currently 13 CLIS).

Limousin Pluralist Expert Group (GEP Limousin)

In order to intensify the dialogue and debate concerning the former mining sites in the Limousin region, the ministries for Ecology and for Health and ASN set up a pluralist expert group in 2006. Composed of about thirty experts from IRSN, various administrations, universities, voluntary organizations and AREVA, the group worked on the basis of a survey carried out by AREVA of the former Crouzille mining division sites and evaluated by IRSN. The group's recommendations were submitted to the Ministry for Ecology and to the president of ASN in September 2010 and aim at renovating and clarifying the institutional and legal framework for the management of former sites, continuing efforts to improve understanding of the impact on the environment and at improving dialogue and debate related to the former mining sites. Some of these recommendations were included in the action plan defined in the 22 July 2009 circular and in the studies requested as part of the PNGMDR.

Conclusion

Fifty years of uranium ore mining in France provided AREVA (and before its creation CEA and COGEMA as well as other mining companies which have since died out) with skills and technical knowledge of the entire mining cycle, from exploration to uranium ore mining, which has today made it one of the world's leading uranium producers. This expertise also includes the decommissioning and rehabilitating of mining sites and the storing of processing residues. It is applied to AREVA's other sites across the world.

The major difficulty in managing former French mining sites is their age (sites closed several decades ago, operated by companies that ceased activities at the same time) and the fact that recommendations and regulations were very different from those currently in effect and the lack at times of any archives.

Almost ten years after the end of uranium ore mining in France, AREVA continues to monitor and check the radiology of residue disposal sites under the supervision of the French administration in a changing legal framework. AREVA also continues to investigate the long-term management of these sites. Likewise, public authorities have adapted the regulations concerning these sites (Mining Code, ICPE, radioprotection, etc) as part of their approach to controlling and monitoring the disposal sites and have implemented action plans such as the National Plan for the Management of Radioactive Materials and Waste or the MEEDDM/ASN circular.

The question is raised concerning the very long term management of these disposal sites which are currently under the control of AREVA: it is necessary to actively prepare their management by defining a legal and institutional framework and by defining a procedure and timeframe for handing over responsibility while identifying the responsible organization; we can draw inspiration from what is being done for former mines where the mining companies no longer exist or from the regulations in place in other mining countries. ■

INTERNATIONAL APPROACHES

The International Atomic Energy Agency's role in safe radioactive waste management

by Denis Flory, deputy director general in charge of Nuclear Safety and Security and Gérard Bruno, head of the Radioactive Waste and Spent Fuel Management Unit – International Atomic Energy Agency (IAEA)

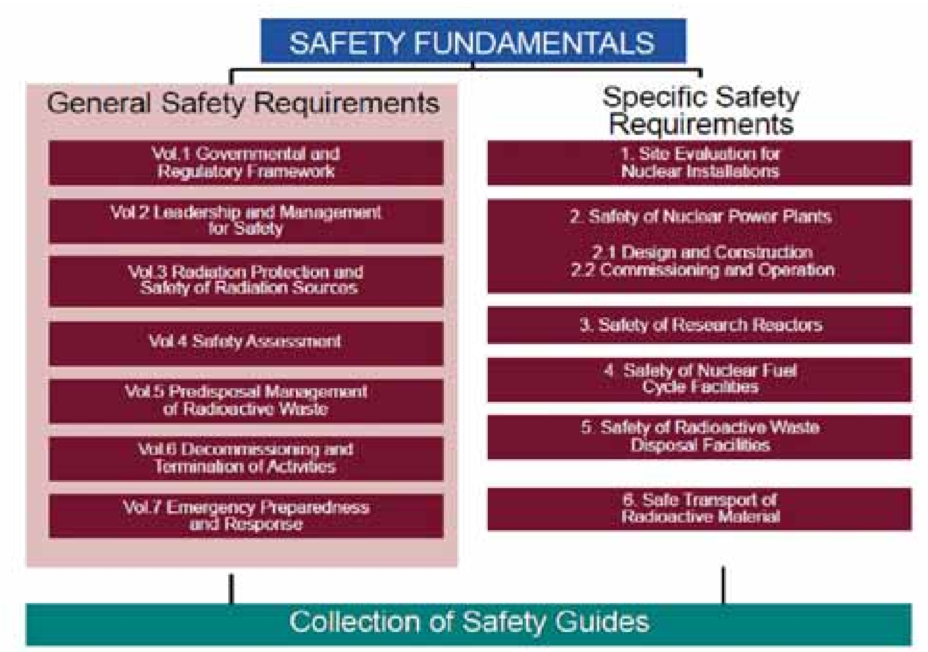


Figure 1: long-term structure of IAEA safety standards

Under the terms of its Statute, the International Atomic Energy Agency (IAEA) is authorized to establish and adopt standards of safety for the protection of health and minimization of danger to life and property. This mission is clearly reflected in IAEA's main programme relating to nuclear safety and security. The programme covers both safety and technological aspects in the area of radioactive waste management.

Work to establish a global framework for waste safety with a view to protecting the public and environment from the harmful effects of ionizing radiation is being carried out within the Nuclear Safety and Security Division which is responsible, in particular, for radioactive waste and spent fuel management. The framework is based on various instruments and actions such as the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention), Safety Standards for the management of radioactive waste of all types and the implementation of measures to apply these safety standards at the request of IAEA Member States.

The safety standards that we issue can be broken down into a hierarchical structure of safety fundamentals, requirements and guides which reflect an international consensus on what constitutes a high level of safety for protecting people and the environment. The process for publishing these standards - approved by the Board of Governors in the case of fundamentals and requirements or by the Director General in the case of safety guides - follows a procedure which ensures international consensus. Consultation of Member States is given an essential role in the process and also involves safety standards committees under the supervision of the Commission on Safety Standards (CSS); the committees and the CSS are comprised of representatives from the Member States.

The safety fundamentals, which were published in 2006, cover in one document the fundamentals which were previously established on the safety of nuclear installations, radiological protection, the safety of radioactive sources and the management of radioactive waste. These safety fundamentals comprise the fundamental safety objective of protecting the public and the environment from the harmful effects of ionizing radiation and the ten principles of protection and safety. They form the basis for the safety requirements.

The safety requirements and guides are currently broken down into a collection of topics which cover the safety of nuclear installations, radiological protection, the safety of radioactive sources, the safety of radioactive waste management, safe transport of radioactive material, general safety and a specific collection for facilities and activities.

A new structure is being implemented for Safety Standards: it distinguishes between general safety requirements and guides and specific safety requirements and guides. Final implementation of this new structure is planned for 2015 (figure 1).

In 2009, the review of the international radioactive waste classification system was finalized. The new classification (GSG-1) covers all types of radioactive waste and establishes in particular a link between the different classes of waste and final management solutions.

The General Safety Requirements document, GSR Part 5 on predisposal management of radioactive waste which was published in 2009 covers predisposal facilities (pre-processing, processing, packaging, handling and storing). The series of safety guides on predisposal facilities currently include the following four guides:

– Predisposal Management of Waste from the Use of Radioactive Material in Medicine, Industry, Agriculture, Research and Education (WS-G-2.7), published in 2005;
– Storage of Radioactive Waste (WS-G-6.1), published in 2006;
– Predisposal Management of Low and Intermediate Level Radioactive Waste (WS-G-2.5), published in 2003;
– Predisposal Management of High Level Radioactive Waste (WS-G-2.6), published in 2003;

In addition, a safety guide on the Safety of Spent Fuel Storage was approved for issuing by the Commission on Safety Standards (CSS) in March 2010.

The CSS has also approved the replacement of the two safety guides on Predisposal Management of Low and Intermediate Level Radioactive Waste and High Level Radioactive Waste (WS-G-2.5 and 2.6). These will be replaced by two specific safety guides: one on Predisposal Management of Radioactive Waste from Fuel Cycle Facilities and another on Predisposal Management of Radioactive Waste from Reactors. In addition to the safety guide (GS-G-3.3) on predisposal management systems published in 2008, a guide on the safety case for predisposal facilities is under development and will be presented to the CSS in spring 2011 for issuing approval.

In terms of the Safety Standards applicable to radioactive waste disposal, the two safety requirements related to surface and geological disposal facilities were combined into one requirements document on disposal facilities. The Board of Governors approved publication of this document in June 2010. The series of specific safety guides related to disposal facilities includes a guide on borehole disposal facilities (SSG-1) published in 2009, a guide on geological radioactive waste disposal facilities which was given approval for publication by the CSS in March 2010 and a guide under development on surface radioactive waste disposal facilities. In addition, a safety guide on management systems for radioactive waste disposal was published in 2008: a guide on the monitoring and surveillance of radioactive waste disposal facilities and a guide on the safety case for radioactive waste disposal are under development.

Along with the development of standards, establishing a global safety framework requires a programme to implement these standards to be developed. The Agency ensures direct application of these standards through national, regional and interregional technical assistance programmes which aim to improve the safety of radioactive waste management in the Member States that put forward a request. Several dozen projects are launched each year to ensure application, in particular through the use of training sessions, specialist missions and workshops which also provide the opportunity to assess management of radioactive waste by Member States and adapt assistance programmes accordingly. We also organize assessment missions upon the request of Member States to evaluate all or part of their radioactive waste management programmes based on the Safety Standards. For example, the Department of Nuclear Safety and Security organized a review of the radioactive waste management activities of the Dutch agency for radioactive waste management in 2009.

The Joint Convention is one of our main instruments for applying international safety standards for radioactive waste management. The IAEA serves as the Secretariat for this Convention which forms a legally binding agreement for Member States. Its aim is to maintain a high level of worldwide safety in terms of the management of spent fuel and radioactive waste. Each Contracting Party of the Joint Convention must draw up a national report presenting its spent fuel and radioactive waste management programme. The report is submitted to the other Parties for a critical peer review which takes place during assessment meetings every three years. One of IAEA's roles, and in particular of the Joint Convention Secretariat, is to develop promotional activities which encourage Member States to adhere to the Convention. In June 2010, for example, along with ASN, ANDRA and the Ministry for Ecology, Energy, Sustainable Development and the Sea, we organized a technical meeting in Paris on the establishment of a radioactive waste management organization.

At present, 57 countries are Contracting Parties of the Joint Convention while in 2009 during the third review meeting there were only 45 Contracting Parties. Despite these encouraging results, we must continue our efforts because all IAEA Member States should adhere to the Joint Convention. The next Joint Convention review meeting will take place in Vienna in May 2012.

As part of our promotional activities related to safe management of radioactive waste and implementation of safety standards, we organize regular international conferences which provide a forum for exchanges on the progress and latest developments of IAEA Member States and also contribute to harmonizing safety approaches and implementation of safety standards. In 2010 we hosted in Vienna the International Conference on Management of Spent Fuel from Nuclear Power Reactors.

Harmonizing safety approaches related to radioactive waste management in particular is an important aspect of IAEA's work in this area. In this connection, at IAEA we place great importance in organizing and developing international harmonization projects which address both the illustration of the safety of surface disposal facilities (Prism project) and deep geological disposal facilities (Geosaf project) as well as projects related to predisposal radioactive management. These harmonization projects are essentially aimed at promoting dialogue between different Member States on their safety measures for managing radioactive waste and contribute towards all Member states reaching a high level of nuclear safety.

IAEA's role in safe radioactive management also concerns safe management of spent sealed radioactive sources. Most countries in the world have to manage spent radioactive sources whether they have a nuclear industry or not. When these sources, which are generally used for medicine, industry or research, reach the end of their life they must be considered and managed as radioactive waste. The Joint Convention is very clear in this respect.

With IAEA assistance, the Radioactive Waste Management Team from Chile's Commission for Nuclear Energy prepares to safely store old radium needles once used for cancer treatment

It is also necessary to take into account the option which is often favored of returning the waste to the original supplying country for recycling or predisposal storage as is highlighted by the implementation of the Code of Conduct on the Safety and Security of Radioactive Sources published in 2004. This often pushes countries to not declare these spent sources as waste in order to simplify cross-border movement. However, return to the country of origin is not always possible, as is the case in particular for sources which were imported before a contractual agreement was concluded between suppliers and recipient countries. This is also the case for "orphan sources". It is therefore necessary for all Member States to develop alternative solutions and establish a strategy for managing spent radioactive sources which includes national storage and disposal options.

IAEA actively supports this approach through its cooperation programmes and initiatives encouraging Member States to develop national strategies. We are also striving to ensure that Member States can fully benefit from the use and application of international instruments such as the Joint Convention, Code of Conduct and Safety standards. In this connection, IAEA organized in October 2010 an international workshop on sustainable management of radioactive sources in Lisbon.

In conclusion, IAEA promotes a responsible, safe and secure approach to peaceful uses of nuclear energy to support numerous countries which have declared the desire to initiate, pursue or extend a programme for nuclear power production. From this perspective it is essential that Member States develop a complete long-term spent fuel and radioactive waste management strategy when they initiate a nuclear power production programme. This strategy must also take into account the need to plan and implement, at a very early stage in the process, a policy for financing activities related to safe management of spent fuel and radioactive waste.

This is why we are pursuing our efforts to assist Member States in developing and implementing these strategies, to assist developing countries in the nuclear industry to build and develop their capacities, to gather solid experience in managing radioactive waste and develop a solid safety culture. This assistance goes hand in hand with the main priority of regularly updating and developing safety standards which meet the expectations of Member States. ■

Deep disposal of spent fuel in Sweden is becoming a reality

by Saida Laârouchi Engström, director of the Environmental Impact Assessment and Public Affairs Department – SKB – Swedish Nuclear Waste Management Organization

As early as the end of the 1970s, the first steps were taken in the process which has only now resulted, almost 30 years later, in a comprehensive proposal for final disposal of Sweden's spent nuclear fuel. In March 2011, Svensk Kärnbränslehantering (SKB) submitted a formal application to build a final repository for Sweden's spent fuel in Forsmark, located north of Stockholm.

The development of the nuclear waste programme was long and informative. Over the years, the focus was on techniques, geology and long-term safety. But we also learnt that having the confidence of the municipalities concerned was just as important in order to succeed.

Challenge of selecting a disposal site

Since the middle of the 1970s, SKB has gathered knowledge of the Swedish geological environment in various manners. Thirty years ago, little was known about the rock at a depth of 500 metres. One of the biggest questions related to underground water. Experts recognized very early on that the groundwater flows through the rock and that the chemical properties of this water were a very important factor for the long-term safety of the repository.

The first step towards finding a site for the final repository began with investigations into site types, carried out between 1977 and 1985. Eight sites presenting different geological conditions were studied both through surveying the soil and by drilling boreholes into the rock. The aim was to have more detailed information about the conditions which are of great importance for final disposal in different geological environments.

There were two main conclusions derived from this work: it seemed there was no one geological environment which could be considered more suitable than another. It became very clear however that the local characteristics of the bedrock were of the greatest importance for the safety of final disposal of spent nuclear fuel.

Willingness is a prerequisite

The second conclusion related to local acceptance meaning that the local population had a positive reaction to SKB's plans. That is why an important measure was to introduce the concept of willingness to participate. This meant that municipalities that were to participate in the siting process would do so on a voluntary basis. SKB has since stuck firmly by this principle.

SKB realized early on what a lack of confidence from the local population could imply. When the first test drilling was carried out at various sites across the country in the 1980s, public disapproval was clear. Inhabitants protested in varying degrees in all the municipalities. In the last area in which investigations were to be carried out - Almunge, located near Uppsala - SKB drilling machines were met with massive protests. SKB decided to suspend work and leave.

A fresh start to siting work

In 1992, serious efforts were put into the site selection procedure. A preliminary questionnaire was sent to all the municipalities asking whether they were interested in participating in the process. Storuman and Malå, in the north of Sweden were the first choices and thus the first feasibility studies were carried out in these two municipalities. However, municipal referendums revealed that the majority of the population was against a repository in their towns. SKB therefore stopped its siting work in these two places.

In parallel with the feasibility studies, the Geological Survey of Sweden (SGU) carried out general geological surveying across Sweden. The results showed that there were suitable areas for final disposal sites in most of the country's municipalities.

In addition to the preliminary studies in Storuman and Malå, SKB also wanted to investigate the existing conditions in municipalities that already had nuclear facilities. Apart from possessing pre-existing infrastructure suitable for nuclear activity, it was thought these municipalities would be more likely to allow SKB to examine the conditions for a repository.

Four municipalities that already had nuclear facilities were considered suitable and were invited to participate: Varberg, Nyköping, Oskarshamn and Östhammar. All but Varberg were willing. Three neighboring municipalities also expressed an interest: Älvkarleby, Tierp and Hultsfred. Feasibility studies were carried out in these six municipalities.

Site investigations in two municipalities

The results of the preliminary studies were studied in great detail and SKB decided that three municipalities were suitable for more detailed investigation: Tierp, Östhammar and Oskarshamn. In November 2001, the Swedish Government approved further site investigations in these three places.

The municipal councils of the three municipalities voted: Östhammar and Oskarshamn were in favor of pursuing their commitment to the siting process, while Tierp declined. From 2002 to 2007, site investigations were carried out in these two municipalities.

During a five-year period, SKB conducted major site investigations involving drilling, analyses and 600 scientific reports on each of the sites. All the data collected was then analyzed, assessed and compared.

Forsmark site north of Stockholm

Selection of Forsmark

In June 2009, SKB decided to request in its application that the final repository for spent fuel be located in the municipality of Östhammar located near the Forsmark nuclear power plant.

SKB safety experts assured that Forsmark presented better prospects for safe long-term disposal and that it would be simpler to carry out the project there. Investigations had shown that Forsmark's bedrock was homogeneous and that it contained very little water at repository depth. This essential safety characteristic also offers advantages for a number of other aspects, for example when tunnels would need to be built and refilled and when containers will be put into place. It allows the bedrock to be used in an efficient manner.

Long-term safety was the deciding factor in selecting the site, but other factors also argued in favor of Forsmark. It is possible to store containers filled with hot spent nuclear fuel closer together in Forsmark because the rock conducts heat better than in Laxemar (Oskarshamn municipality). This means that the size of the repository in Forsmark would be smaller and would thereby simplify its construction and reduce the amount of rock to be excavated.

Moreover, the facility in Forsmark would be built close to an existing industrial area. This limits the environmental surface impact and provides access to facilities located in the area.

Importance of communication and transparency

In the final phase of the process - site investigations in two locations - SKB placed even greater importance on communication and informing local stakeholders. Particular emphasis was put on maintaining personal contact with the landowners of the sites where studies were being carried out as well as with those living close by.

It was also important to make contact with the other inhabitants of the municipalities. This was achieved by acquiring information from associations, businesses and anyone living in either municipality. Every household in both municipalities also received the local SKB newsletter, Lagerbladet, and most decided to visit the existing SKB facilities in the two sites. Over the years, thousands of inhabitants from Oskarshamm and Östhammar visited each other's municipality.

Thirty years of research

During the time that was needed to find a suitable site, SKB researched a method that would satisfy long-term safety requirements. There are three cornerstones of SKB's research and development: natural science research, technology development and social science research. Once every three years SKB submits a programme to the Swedish Radiation Safety Authority.

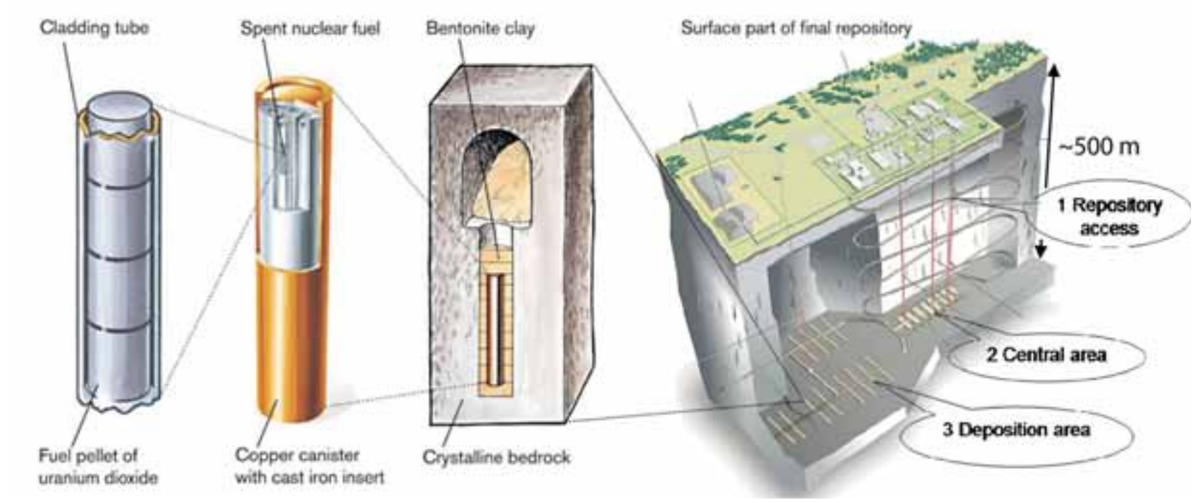
This programme includes SKB's research and development plans for building a final repository for various types of radioactive waste (short-lived, long-lived, spent nuclear fuel). The programme is reviewed by the Authority and by a number of other organizations which are consulted. It is then approved by the Government.

The aim of our scientific research is to enable understanding of how conditions in the different final repositories change over time and how this affects safety. This research will also supply the data needed to construct the barriers of the final repositories in a functional and financially efficient manner.

A number of experiments are being conducted under realistic conditions in SKB's underground laboratory, the Äspö Hard Rock Laboratory located outside Oskarshamn. Research is also being carried out in the Canister Laboratory and the Bentonite Laboratory, as well as at universities and colleges in Sweden and abroad. Many research programmes are also carried out in cooperation with nuclear waste management programmes in other countries.

An important stage awaits us

In March 2011 SKB plans to submit an application to build a spent nuclear fuel repository in Forsmark . We will then tackle an important stage during which the environmental impact (in



accordance with the Environmental Code) and the long-term radiological safety requirements (Law on Nuclear Activities) will be evaluated.

It is the Swedish Government that will ultimately decide, after consulting the municipalities concerned that can exercise a right to veto.

This stage should be finalized in 2014. In the case of a positive outcome, construction could start in 2015 and the first container of spent nuclear fuel could be emplaced in the bedrock repository in Forsmark around 2025.

Information on Sweden's radioactive waste programme

Swedish system

Short-lived radioactive waste is disposed of in a final repository in Forsmark (SFR). This waste is packaged in metal or concrete containers and stored at a depth of approximately 50 metres in rock vaults that are kept under surveillance. Spent nuclear fuel is deposited in an interim storage facility outside Oskarshamn (Clab) in two storage pool systems 30 metres down in the bedrock that are kept under permanent surveillance and control. The fuel is transported using a specially-built ship, m/s *Sigyn*.

SKB also manages two research laboratories. The Äspö Hard Rock Laboratory, situated north of Oskarshamn, is an underground laboratory in which SKB conducts research and develops methods in a real environment and on a full-scale. In the Canister Laboratory in Oskarshamn, methods for encapsulating spent fuel are developed and tested. Methods for manufacturing, sealing and inspecting the quality of the copper canisters have also been developed.

Repository for spent nuclear fuel

SKB's final repository for spent nuclear fuel will keep nuclear fuel isolated for 100,000 years.

SKB's method consists in disposing spent nuclear fuel in the bedrock at a depth of approximately 500 metres with a system of various protective barriers. The first barrier is made up of a copper container which encapsulates the spent nuclear fuel. Its role is to isolate the fuel from the environment. It is impossible for any radioactive substances to escape from the sealed container. Inside the containers is a cast iron insert in which the spent fuel is placed and which is designed to resist the mechanical forces of the rock. The containers are then embedded in bentonite clay which swells when it absorbs water. Bentonite acts as a buffer. It protects the containers from rock movements and evacuates any residual heat. At the same time, it serves as a filter and stops radioactive substances from being carried by groundwater to the surface if the containers are damaged.

The surrounding rock also delays the release of radioactive substances. Its main role, however, is to protect the containers and bentonite from events on the ground surface. The rock will also provide a stable chemical environment for the other barriers.

Decision-making process

A permit in accordance with the Environmental Code and the Law on Nuclear Activities is required to build and manage a final repository for spent nuclear fuel.

The Environmental Court checks that the request complies with the Environmental Code once the Government has decided whether the operation is permitted or not. If the Government decides that it is admissible, the Environmental Court lays down the conditions. The Government grants authorization in accordance with the Law on Nuclear Activities after the Safety Authority has communicated the terms and conditions. Before the Government decides, the municipality selected is consulted.

Future financing

SKB's activities are financed by way of a fee paid by nuclear power plant owners. Since 1982, fees have oscillated between SEK 0.01 and SEK 0.02 per kWh delivered from the nuclear power plants. Currently, nuclear utilities are paying about SEK 0.01 per kWh. Assets are managed by the Nuclear Waste Fund.

Who does what in Sweden's radioactive waste programme?

SKB handles spent nuclear fuel and other radioactive waste from nuclear power plants, hospitals, industries and research establishments in Sweden. SKB also conducts research and provides information on its activities.

The Swedish Radiation Safety Authority carries out inspections of nuclear power plants as well as of all nuclear activities in Sweden. Its role is to inspect and set requirements for those carrying out nuclear activities to ensure that radiation protection and safety provisions are complied with. This also includes the transport, treatment, interim storage and final disposal of radioactive waste. In accordance with the Law on Nuclear Activities, SSM is examining SKB's application to build a spent nuclear fuel repository in Forsmark.

The Swedish National Council for Nuclear Waste is a scientific committee attached to the Ministry for the Environment and is tasked, in particular, with giving the Government and authorities concerned advice on nuclear waste. The Swedish National Council for Nuclear Waste is also responsible for sharing its independent opinion in a special report issued every three years on the level of knowledge in the area of nuclear waste.

Every three years, the Swedish Government takes a stand by way of a Governmental Decision on SKB's plans which are submitted as a Fud report (research, development and demonstration report). The Government examines its admissibility in accordance with the Environmental Code and grants authorization in accordance with the Law on Nuclear Activities for SKB's applications with a view to building a final repository for spent nuclear fuel in Forsmark.

The Environmental Court examines SKB's application to build a repository for spent nuclear fuel in Forsmark, in accordance with the Environmental Code.

The municipalities of Oskarshamn and Östhammar have set up special working groups for ongoing monitoring and control of SKB's activities.

Environmental organizations take part in our dialogues, seminars and consulting activities relating to SKB's research and development programme. One example is the Swedish NGO Office for Nuclear Waste Review (MKG) which is financed by the Nuclear Waste Fund. ■

INTERNATIONAL APPROACHES

Harmonizing nuclear safety practices in Europe:
WENRA (Western European Nuclear Regulators Association) activities in the area of waste management

by Stefan Theis, chairperson of the WENRA Working Group on Waste and Decommissioning (ENSI), **Géraldine Dandrieux,** representative of France in the WENRA Working Group on Waste and Decommissioning (ASN) and **Fabien Féron,** representative of France in the WENRA Reactor Harmonization Working Group (ASN)

Introduction
by Stephan Theis

The Western European Nuclear Regulators Association (WENRA) was founded in 1999 and was originally comprised of the heads of nuclear regulatory authorities of EU countries and Switzerland.

The original objectives of the Association at that time were to:
– develop a common approach to nuclear safety and regulation, particularly within the European Union;
– provide the EU with an independent capability to examine nuclear safety and regulation in candidate countries;
– evaluate and then adopt a common approach to nuclear safety and related regulatory issues.

To perform these tasks, WENRA launched two working groups, first the *Reactor Harmonisation Working Group* (RHWG) and shortly after the *Working Group on Waste and Decommissioning* (WGWD).

The basis for all WENRA work is the Policy Statement which includes a commitment by all WENRA members to continuous improvement of nuclear safety and to implementing without undue delay harmonized requirements produced by the working groups after approval by the WENRA plenary. The first WENRA publications to receive interest from the public and the industry mainly concerned the operational safety of nuclear power plants. More recently, the RHWG published its study at the beginning of 2010 on new reactors which led to the publication of a WENRA Statement on the safety objectives for new nuclear power plants in November 2010. The RHWG also launched studies on the safety of existing reactors.

Several documents touched on the first few years of WENRA since its creation. After an article appeared in a previous edition of this review (*Contrôle* n° 181) which focused on the decommissioning of nuclear facilities, a brochure was written on WENRA's history on the occasion of its tenth anniversary *(The first ten years of WENRA activity)*. This article aims to present WENRA's other activities related to the various aspects of national waste management and in particular some of the specific areas studied by the Working Group on Waste and Decommissioning.

Unlike the operation of major nuclear facilities, such as enrichment or re-processing plants and nuclear power plant sites, installations and practices at the end of the nuclear fuel cycle do not raise as much public interest or only occasionally, for example when decisions concerning new projects or the selection of a new disposal site are being made,. As a result, the resources allocated to these areas by all stakeholders are, at times, insufficient.

This state of affairs may explain why a very limited number of countries across the globe have implemented a completely coherent waste management system. Despite the commitments made by high-level politicians, for example the signature of the Convention on Nuclear Safety and Joint Convention, and despite the fact that most countries have affirmed that they have defined perfectly clear and coherent waste management principles, in many cases these principles are not fully implemented as a part of ongoing management. The work of the WGWD (Working Group on Waste and Decommissioning), which focuses on technical aspects, is of significant value in this context since its members often occupy positions lower down in the hierarchy than the directors and commissioners who may also have political responsibilities in their countries. Moreover, WGWD members are high-ranking experts with technical responsibilities in their respective countries, and are in charge, in particular, of amending their country's nuclear legislation and of publishing implementation guides. In many cases, the members are precisely the people who are in a better position to commit to and progress the amendment of these documents with a view to implementing WGWD's safety reference levels.

In addition, the members of WENRA's working group have another advantage in that they are also in charge of checking implementation through the evaluation of inspection reports and the monitoring of proper application of regulations.

WENRA's integrated approach to radioactive waste and spent fuel management

As part of the mission for WGWD's latest project - the storage report - WENRA's Management Committee approved WGWD's long-term programme which takes account one-by-one of all the steps and main activities at the end of the nuclear fuel cycle:
– decommissioning after final shutdown of a nuclear facility;
– production of nuclear waste;
– treatment of waste and spent fuel;
– storage of waste and spent fuel;
– disposal of waste and spent fuel.

A report will be published for each of these issues indicating the specific requirements and the safety reference levels with which the national legal systems of the different Member States and the operating practices can be compared.

The initiative in the most advanced stage is the report on storage, followed by the report on decommissioning and finally the report on disposal. Work will be started in the near future on the production and treatment of waste.

Storage safety reference levels: an illustration of WENRA's approach

WENRA's specific approach can be illustrated by a detailed analysis of the major steps of the report on storage:
– step 1: gathering requirements (safety reference levels – SRL) for all issues pertaining to safety. The requirements are based primarily on IAEA requirements as well as on the experience of members of the working group. The SRLs are classified into safety areas:
- safety management;
- design;
- operation;
- safety verification.

– step 2 : comparison of national legal systems against SRLs
- each WENRA member state writes up an evaluation of the way in which each SRL is taken into consideration in national legal systems and is implemented at specific installations;
- all of these documents are examined by the working group in plenary session or by a smaller committee;
- the results are established according to three criteria: compliance, justified non-compliance or non-compliance requiring a corrective action plan.

– step 3: implementation of national action plans to correct identified discrepancies by integrating the missing SRLs in the national legal system.
– step 4: approval of the action plans and benchmarking exercise.
– step 5 (optional): review of the report defining the SRLs in order to integrate any lessons learned from step 2.
With regard to the report on storage, the evaluation of the first step was published in September 2006 as version 1.0. The second step was completed at the end of 2009 after all the national action plans were developed and the comparison exercise of the national legal systems with the SRLs in report version 1.0 was carried out.

Work related to step 5 was conducted in parallel to the benchmarking exercise and led to the publication of version 2.0 of the storage report in May 2010. Work related to steps 3 and 4 is currently underway and will continue until 2012. The way in which WENRA members implement the safety reference levels differs slightly according to the structure of their national legal system. However, in many countries priority is given to the publication of new regulatory guidelines or to amending existing guides to ensure that any missing requirements are implemented. ■

Implementation of safety reference levels in France

by Géraldine Dandrieux

The changes being made to French regulations are a good illustration of step 3.

Like all WENRA members, the ASN is committed to integrating the safety reference levels defined by WENRA in its own regulations. This task is being carried out in close cooperation with the ASN's project aimed at an extensive review of French regulations on nuclear facilities.

This approach comprises three steps:
– the first step relates to the integration of general requirements applicable to all types of nuclear facilities. The objective is to integrate the safety reference levels defined by the RHWG, such as the requirements relating to a nuclear safety policy, management system, etc. These requirements were introduced in the draft order on the general regulations applicable to nuclear installations;
– the second step is to include specific requirements for waste management facilities in the draft order based on the safety reference levels which were defined (or are being defined) by the Working Group on Waste and Decommissioning. The new provisions will focus, in particular, on the issue of storage facilities and their specific nature as well as disposal facilities. A chapter is also dedicated to decommissioning;
– in the third step, the high-level requirements listed in the draft decree will be more fully detailed using decisions of the ASN as a basis. For example, a decision on waste management has already been submitted to the stakeholders at national level for consultation. In addition, the ASN is currently working on two decisions: one on storage facilities based on a report written by the Working Group on Waste and Decommissioning, the other on disposal facilities. Although the WENRA working group is currently drawing up the report on disposal facilities, the productive discussions within this group have greatly contributed to structuring the ASN's approach.

As a member of the ASN tasked with drawing up new regulations, I can affirm that the safety reference levels defined by the Working Group on Waste and Decommissioning and, more generally, the work carried out by the association, provide a solid basis on which national safety authorities can develop their legal frameworks as part of the harmonization process at European level.

Status of other WGWD activities

After the report on storage facilities - which is at its most advanced stage - is published, a second WGWD report on decommissioning should follow within one to one and a half years. However, the benchmarking exercise of comparing with decommissioning safety reference levels defined by the WGWD was limited to national regulations since in many countries there were no decommissioning projects either under way or completed. The deadline set for implementing the national action plans is 2013 for the decommissioning safety reference levels; version 2.0 of the report on decommissioning will be published in 2012.

After implementing WENRA's approach in the context of work on storage and decommissioning, at the end of 2009

An IAEA safeguards inspector seals a transport container storing nuclear fuel

the WGWD started work on the most difficult report which concerns disposal. The difficulty of this task is linked to many aspects including the various approaches to disposal techniques (subsurface/deep geological disposal), the multitude of source terms (from low-level waste to spent fuel and high-level waste from reprocessing) and the scale of time for long-term safety (from hundreds of years to geological time scales). The working group receives additional assistance from waste disposal experts provided by some member countries.

The two other subjects covered in the integrated approach - waste production and waste treatment - will be dealt with at a later time as soon as the members of this working group are able to start work.

Specific advantages of WENRA's approach

Like many other activities such as the IRRS missions and triennial reports submitted during the Nuclear Safety Conference or Joint convention conferences, WENRA's approach aims at improving the level of nuclear safety and at harmonizing the requirements of the various countries. An important difference, however, is that WENRA does not look to attain its objectives by carrying out targeted surveying missions aimed at identifying cases of non-compliance or by the intervention of high-level international groups of experts who make recommendations but do not assist the countries in solving the problems identified. WENRA's approach must be seen as an integrated process which is implemented over many years and on a mutual basis. The process begins with the adoption of a consensus on the necessary requirements to guarantee the nuclear safety of a type of installation or specific practice. The implementation of steps 1 to 5 in a relatively long but consistent process and the commitment of WENRA member countries together ultimately constitute the quickest and most efficient way of setting up harmonized requirements in all of the association's member states.

As we can gather from the information provided by numerous contacts, WGWD's reputation amongst the operators as well as other international organizations has changed considerably as the advantages of our approach have become more and more apparent. This change is shown by the increased demand from operators and also representatives of the IAEA and other organizations for technical discussions. Currently, the number of countries interested in participating in WENRA's work has gone beyond the 17 member countries and some counties are already attending meetings as observers.

Finally, it is important to recognize that intense discussions on legal requirements within groups of experts such as WENRA's working groups provide a unique opportunity to gain access to many long years of experience in legal systems, to establish a common platform of knowledge and to improve mutual understanding of key aspects of regulations such as safety actions, the graduated approach and global/integrated waste management systems. ■

Integration of WENRA's reference levels in the French legal system

by Fabien Féron

The Reactor Harmonization Working Group (RHWG) has developed some 300 reference levels related to 18 safety areas (safety policy, management system, periodic safety verification, etc.) with a view to harmonizing the applicable regulations in Europe for reactors currently in operation. These reference levels were published in 2006 and updated in 2007 and 2008.

After a comparison of French regulations and recommendations with WENRA's reference levels, the ASN developed an action plan to integrate all the reference levels. Since almost 2/3 of the reference levels were not fully integrated into existing French regulations and recommendations, the ASN launched work on a draft Ministerial Order and a number of guides to take these requirements into account. The reference levels were divided among the different documents to be written up in order to ensure that each working group tasked with drafting a text has full knowledge of the reference level to be integrated.

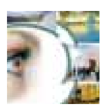
After the Law on Nuclear Transparency and Safety (TSN Law) was published in June 2006, the ASN evolved into an independent administrative authority. It was no longer empowered to formally sign a Ministerial Decree but instead was able to define legal requirements in the form of decisions. As a result of this new development, a new roadmap was set up to transpose WENRA's reference levels using an approach aimed at broadening as far as possible the application of these reference levels to all nuclear installations. This lead to the establishment of the following new legal architecture: a Ministerial order, a dozen decisions of the ASN and a number of guides for transposing all reference levels into the French legal system. Most of these documents have been handed over to the parties involved for their feedback. The few remaining texts will be submitted for consultation in the following months.

The ASN created two instruments aimed at ensuring that the reference levels are transposed in full:

– for each text being drafted, a table lists the reference levels which have been transposed either fully or in part;

– for each safety issue, a table summarizes the texts already published or in the course of being drafted which transpose the reference levels and identifies the document in which they can be found.

The following three challenges must be met throughout the drafting process of the legal texts:



– ensuring the consistency between the different texts being drafted (between the order and the decisions but also among the ASN's decisions themselves which are often written up in parallel);

- avoiding the repetition of reference levels (although it is possible that some reference levels may be found in different safety issues);

– identifying the reference levels which, not specifically relating to power reactors, can be applied to all nuclear installations.

Given the scale of the work to be carried out, the ASN created a review committee (COREL) tasked with reviewing all draft texts before they are submitted to stakeholders for their views and after the documents are updated in order to take into account the results of the consultation process. The review committee is composed of representatives from each of the ASN's departments, representatives from the divisions and a representative of the IRSN. None of COREL's members are involved in the working groups tasked with drafting the texts. Its role is considered to be vital to the drafting work of these legal texts. ■

VIEWPOINT HELD BY ASSOCIATIONS AND CONSULTATION BODIES REGARDING WASTE MANAGEMENT

Bure CLIS: role, operation, disposal project

by Benoît Jaquet, secretary-general, Local information and oversight committee in Bure (CLIS)

The local information and oversight committee (CLIS) is an independent body which has been charged by successive laws (30 December 1991 and 28 June 2006) with monitoring the research being carried out by the French National Agency for Radioactive Waste Management (ANDRA) in and around the Bure laboratory as part of the studies on radioactive waste management and in particular on deep geological disposal of this waste.

Its role is to inform the general population, in particular the inhabitants of the Meuse and Haute-Marne departments, of the research, its results, the underground disposal project and its stakes. The CLIS is therefore the chosen contact for local inhabitants. It is also called upon to promote dialogue relating to a project during the long decision-making process. This makes it a distinct body with a role and operating method which is very different from those of local information committees set up within the vicinity of nuclear installations.

Visit of the local information and oversight committee in Bure (CLIS) to Tournemire

Composition of the CLIS

The CLIS has 90 members including representatives of the state (Préfets of the Meuse and Haute-Marne departments, of the Regional Departments for the Environment, Planning and Housing (DREAL) of Lorraine and Champagne-Ardenne), of the French Parliament (2 MPs and 2 senators), of local councils (regional councils of Lorraine and of Champagne-Ardenne), general councils of the Meuse and Haute-Marne, 29 municipalities in the Meuse department and 18 municipalities in the Haute-Marne department located in the zone of proximity of the laboratory), of professional associations and bodies (including those created in protest against the project) and of medical professions. It also includes qualified specialists (including a geologist and a nuclear medicine specialist). ANDRA and the ASN also sit on the committee, but for consultation purposes only.

The CLIS, which was created in 2008 as an association and is chaired by an elected member (currently Jean-Louis Canova, General Councillor of the Meuse and Mayor of Ancerville), has an annual budget of approximately EUR 300,000 (including the salaries of the three permanent staff members), financed in equal parts by the French government and waste producers. It carries out the tasks assigned to it by law (information, consultation, monitoring) through a large number of actions:

– public hearings (during which each year the National Review Board presents its report) open to the media;
– public meetings in the municipalities located in the zone of proximity;
– biannual publication of the CLIS newsletter (sent to every inhabitant of the Meuse and Haute-Marne departments, which represents 165,000 copies);
– insertions in regional daily newspapers (Est Républicain and Journal de la Haute-Marne);
– provision of a collection of documents in Bure;
– website (www.clis-bure.com);
– training of members (geology, geomechanics, hydrology, earthquakes, etc.) and visits to typical sites (in France to understand the nuclear cycle and abroad to gain knowledge of and compare nuclear waste management policies);
– welcoming of French and foreign delegations in Bure;
– participation in activities of the ANCCLI (National Association of Local Information Committees and Commissions) and the OECD's Nuclear Energy Agency and in research activities within the framework of European Commission programmes (COWAM 1 and 2 and COWAM in practice);
– requests for independent assessments or second opinions (for the laboratory's environment monitoring plan, the experimental programme of ANDRA's laboratory and for issues related to geothermal resources).

The activities are organized by the Board of Management, which is composed of 23 members representing the different categories of the CLIS and which meets 6 to 8 times a year and can also interview experts in order to gain deeper knowledge of specific subjects.

Some topics are dealt with by commissions created within the CLIS (made up of 8 to 25 members). Their work focuses on communication (defining measures, media, drafting of content), location of a potential disposal site (discussions on the transposition of geological data, length of storage of waste packages pending final disposal and transportation), health and the environment (safety efforts, protection of the environment and of the general public, including a request for a health reference reading put forward in 2000) and reversibility. The commissions can also call upon external contributors. They render account of their work on a regular basis during plenary sessions and are empowered to propose initiatives in their field.

Due to the progress of ANDRA's project (location now narrowed down to a restricted zone) and the deadlines stipulated by the law, in 2010 the CLIS implemented three major measures:
– organization of public meetings in the municipalities located in the zone of proximity in order to gather questions and observations from inhabitants directly affected by the project. Hosted by two to three members of the CLIS, these meetings will provide an opportunity to promote the CLIS while demonstrating the diversity of its members' opinions depending on the subject and above all to enable those who are either unused to or rarely given the opportunity of doing so, to express their opinion in a very open context on a project which is often considered to be too complex and the completion of which seems in a far too distant future.
– assessment by an independent body (selected after an international bid for tenders) of ANDRA's research which led to the proposal of a restricted area of interest for in-depth investigation ('ZIRA'), a 30 km² area in which the disposal facilities would be built if authorized, which would enable CLIS to submit a well-documented opinion to the French government (who requested it) on ANDRA's proposal;
– development of a programme and a work method for the 'reversibility committee' so that it can develop its own analysis of the idea based on the concept proposed by ANDRA (which seems rather to correspond to retrievability until final shutdown) and enable the CLIS to participate in the discussions leading up to the approval of a law on reversibility conditions in 2015. The CLIS has already been working on this subject for many years since in March 2001, in Bar le Duc, it organized an international symposium on "Reversibility and its limits".

These three initiatives aim to meet the different objectives pertaining to the tasks of the CLIS: disseminating its own information to as many people as possible so that they can participate in a useful manner in debates taking place throughout the process, and become players in their own right at each step where their contribution is needed and also when it is not specifically planned. ■

The ASN's viewpoint
by Michel Babel, head of the Châlons-en-Champagne division

In accordance with the provisions of Decree 2007-720 of 7 May 2007 concerning the composition and operating procedures of the CLIS in BURE, the Châlons-en-Champagne division attends the general meetings and the meetings of the Board of Management, providing any details needed to fully inform the members of the CLIS. It also contributes to the work of some of the commissions set up by the CLIS (communication, reversibility) and has helped some working groups focusing on geothermal energy, the future of the CLIS and the assessment of ANDRA's work and projects.

The CLIS plays a vital role in ensuring that local populations are well informed and the ASN welcomes the initiative taken recently by the 'communication' commission to visit the municipalities to engage in direct dialogue with the inhabitants.

The debates within the CLIS are useful and necessary, but it is important to ensure that they are not an obstacle to CLIS's actions. It must be understood that the CLIS is not a vehicle for personal opinions whether for or against the disposal project; there are other occasions or ways of expressing these. The CLIS must strive to provide information which is as objective as possible and as quickly as possible so that instead of rumors abounding, each person can have an informed opinion. ■

ASN inspection of the ANDRA laboratory in Bure (Meuse/Haute-Marne)

VIEWPOINT HELD BY ASSOCIATIONS AND CONSULTATION BODIES REGARDING WASTE MANAGEMENT

Waste: action taken by the CLIs and the ANCCLI

by Monique Sené, vice-chair of the Scientific Committee and of ANCCLI (The National Association of Local Information Commissions and Committees)

Motivations of the CLIs and the ANCLI

Local information committees (CLIs) were first set up in the autumn of 1981 following a simple circular ('Mauroy circular') issued by the Prime Minister at the time. They were preceded by the campaign of Solange Fernex (European MP and activist for the committee for the protection of Fessenheim and the Rhine valley) to create a local monitoring committee located in close proximity to the Fessenheim plant.

The CLIs pool together their experiences, information and expertise within the ANCLI (new body created in 2000).

The CLIs and, therefore, ANCLI have a "broad mission of communication, monitoring and expertise concerning the operation of nuclear sites and their impact on public health, the environment and the economy, throughout their operational lifetime and beyond".

The CLIs act at local level but share their experience and carry out joint actions under the umbrella of their association, the ANCLI (ANCCLI since 2009).

When two public debates were announced, one on waste management (2005) and the other on the European Pressurized Reactor (EPR - 2006), the ANCCLI set up a working group to investigate the subject of "Local Governance of nuclear sites" which published its findings in May 2005.

The extremely positive reaction this Paper received, both from the CLIs and from political circles, encouraged the ANCCLI to initiate a study focused more directly on nuclear waste management. This work resulted in the publication of the "Livre Blanc de l'ANCCLI - Matières et déchets radioactifs/territoires" [ANCCLI's White Paper on radioactive materials and waste and local communities (June 2006)]. This Paper was published after the Law of 28 June 2006 relative to the "National policy on sustainable management of radioactive materials and waste" was passed, but the key ideas had been communicated to the French parliament.

The ANCCLI had pressed for the creation of a pluralist national standing committee (CNPP) which would enable the civil society to monitor files relating to nuclear energy.

Instead, the Law created the French High Committee for Transparency and Information on Nuclear Security (HCTISN). The HCTISN (article 10 of Law 2006-739) is tasked with periodically organizing *"consultations and debates concerning sustainable management of radioactive material and waste"*. We can therefore hope for a certain amount of monitoring by the civil society as well as the communication of the various aspects of its work to citizens.

However, the ANCCLI cannot be dependent on an intermediary, even one as important as HCTISN and therefore announced that *"if the creation of a CNPP is not included in the 2006 Law, the ANCCLI will create the committee on its own initiative with the players who wish to participate"*. In any case, the ANCCLI intends to play an active role in accordance with article 7 of the Constitutional Charter for the Environment which states: *"Each person has the right, under the conditions and to the extent provided for by law, to have access to any information pertaining to the environment in the possession of public bodies and to participate in the public decision-making process likely to affect the environment"*. In addition, the ANCCLI wishes to contribute to *"improving the management of radioactive material and waste in France by taking an accurate account of the concerns and role of local players"*.

The ANCCLI therefore set up several working groups: The Standing group on radioactive waste and material, the Standing group on the safety of nuclear power plants and the Standing group on post-nuclear accidents issues.

In cooperation with the IRSN, the ANCCLI coordinates several mixed groups: health impact and access to expert knowledge.

At European level, the ANCCLI also participates in various workshops (in connection with the European Union) which assess the conditions in which the Aarhus Convention is applied in the 26 Member States.

Initiatives supported by the ASN, the IRSN, the Ministry for the Environment, the European bodies (ENEF and DG TREN) and local organizations

A. Symposium: "Tritium: invisible, but everywhere"
4 and 5 November 2008. Led by the ANCCLI, in association with the local information committee (CLI) for the installations on the Saclay plateau

The primary objective of the permanent working group on radioactive materials and waste of ANCCLI (GPMDR) is to involve the CLIs in monitoring the application of the Programme Law of 28 June 2006 on the sustainable management of radioactive materials and waste.

Article 4, for example, establishes a programme of analysis and research aimed at *"the development by 2008 of storage solutions for tritiated waste which will enable their level of radioactivity to be lowered before disposal in surface or subsurface repositories"*. The working group of ANCCLI on radioactive materials and waste has therefore started to address this problem.

■ Why a symposium?

An initial inventory was drawn up covering the quantities of natural and artificial tritium present in the environment in the world and more specifically in France, the present state of knowledge and research into the harmful effects of tritium on health, methods of treating this waste, discharges from nuclear installations and the justification for them. The Scientific Committee of the ANCCLI was approached, and produced a book *(Le tritium: actualité d'aujourd'hui et de demain - Tritium: the issues now and in the future, published by Lavoisier, 2010)*. The Group set up a web site listing the available documentation on the subject, and organized a symposium to take stock of current knowledge and the challenges posed by tritium. The objective is to enable the CLIs to engage with the discussions sufficiently in advance to able to influence decisions when the time comes.

The symposium

The symposium brought together delegates from every field (50 representatives from the CLIs and 50 from various other bodies).

It helped to assess the position regarding tritium by listening to the different points of view. In particular, the discussions threw up a distinction between tritiated discharges (from nuclear reactors, treatment plants, etc.) and tritiated waste (mostly of military origin), which deserves more in-depth analysis. Management by dilution (discharge) is one option for handling waste, as opposed to management by disposal or storage (concentration of waste in a matrix, followed by packaging).

Conclusions from the symposium

The various presentations helped to establish the position and initiate dialogue on:
– tritium in the environment: the processes of dispersion (bio-accumulation, bio-amplification, bio-concentration);
– the impact of tritium on health: this material (radioactive hydrogen) is very mobile. Various scientific findings suggest that we need to review the data on the effects of tritium;
– the option of management by discharge: this needs to be re-examined. We cannot contemplate an increase in tritiated discharges from the various sites that produce these without thorough analysis. Many scientific uncertainties emerge, and research is needed to fill in the gaps in our knowledge of the effects of tritium. As pointed out by some of the delegates at the Orsay symposium, the EU REACH Directive requires proof that chemical substances are harmless before granting authorization for them to be placed in the market.

Recommandations

– continue research on tritium, particularly its organically bound forms;
– do not allow any increase in discharges of tritium until the effects of chronic exposure to this substance are better understood;
– monitor the situation.

The ANCCLI and the CLIs will continue to work within the permanent group to address the issues set out in the Act of June 2006 (LL-LLW, reversible disposal, mining waste).

B. The ACN programme (Aarhus Convention & Nuclear): A joint initiative of the ANCCLI and the European Commission

24 and 25 June 2009 (Luxembourg): European workshop on the practical implementation of the Aarhus Convention in the nuclear field

The objectives of the European workshop on the practical implementation of the Aarhus Convention in the nuclear field were to:
– draw up an initial review of the application of the Aarhus Convention in the nuclear field, particularly in legal and governance terms (session 1);
– use specific cases to review and analyze current practice and difficulties in three key areas: participation, transparency and the cross-border dimension (session 2);
– open up discussions on the initiatives that might be taken following the Luxembourg workshop, propose and debate a methodology to support these initiatives, and decide on the next steps (session 3).

Following this workshop, national round tables will be established in the interested Member States to gather feedback at the national level. These round tables will bring together a multi-disciplinary group of stakeholders with significant representation from civil society, and will focus on different nuclear issues:
– monitoring nuclear installations (environment and safety);
– radioactive waste;
– incident and post-incident management;
– new plants;
– decommissioning.

This approach will enable the different stakeholders, by a process of exchange and dialogue, to identify possible ways forward in each country. In parallel, European round tables could be established to analyze horizontal issues or questions of a truly European nature. A further round, in a conference to be held no earlier than 2010/2011 (depending on the progress made by the national round tables), will allow us to develop a European vision and to assess the actions to be taken in a sustainable manner in order to improve transparency in the nuclear field at the European level.

Taking water samples from the Etang Neuf lake near the CEA centre in Saclay for radiological and physico-chemical analysis.

26 November 2009 (Paris): meeting of the French Steering Committee for the ACN initiative

Following a round of feedback and discussion, it was agreed to work on three issues:
– the process of selecting sites for LL-LIL waste;
– public access to information and participation in decision-making;
– skills to be developed and expert opinion to be called upon to assure true participation.

Three working groups were set up:

• Working group 1 (WG1) *LL-LIL waste ACN France,* led by the GPMDR of the ANCCLI (co-lead: HCTISN):
WG1 is made up of people nominated by the bodies represented at the ACN France round table that expressed an interest in this topic. The lead body ANCCLI is represented by members of its GPMDR and representatives of the Bure CLIS (local information committee on safety). Other people may be involved in this work as and when needed. WG1 will draw up a report on the process of site selection, its exposure to public debate, the inventory of types of waste, and feedback from experience with the Manche repository.
WG1 will organize interviews with people involved in the disposal of long-lived low and intermediate level waste (associations, mayors, citizens, etc.)

• Working group 2 (WG2) led by Greenpeace France (co-lead: ASN) on public access to information and participation in decision-making.
WG2 will work on the following issues: status of French procedures inspired by or conforming to the Aarhus Convention, assessment of the operation of these procedures to analyze their real effectiveness, and research into possible ways forward.
WG2 is working on actual cases: the decommissioning of the Brennilis plant, the objectives of the public debate and coordination with public enquiries.

• Working group 3 (WG3) led by IRSN (co-lead: ANCCLI) on the skills to be developed and expert opinion to be called upon to assure true participation.
WG3 proposes to study actual cases. In particular, an analysis of the work done in 2008/2009 by the CLIs with the assistance of IRSN will be carried out in the light of the Aarhus Convention. The question of the objectives of the expert opinion (what is it for? who is it aimed at?) and of following up its conclusions or recommendations may also be addressed.

8 and 9 April 2010 (Luxembourg): European round table on the "Application of the Aarhus Convention to the field of radioactive waste management"

The issues of access to information, participation and access to justice gave rise to stimulating and constructive discussion based on specific case studies from different Member States. These discussions highlighted the importance of European support for initiatives launched in the Member States to improve transparency and participation in the sphere of waste.

The representatives of the different States (12) reported on the organization of consultations in their respective countries. The target of the end of 2011 still seems feasible for the organization of a follow-up conference to assess progress with regard to the Aarhus Convention and its application at the European level.

And to conclude: the ANCCLI is pursuing its European approach supported by both French and European bodies.

There is no doubt that these discussions between European citizens benefit everybody. We must hope that these initiatives help to guarantee a high-quality environment and health policy for all.

What is the future of the ANCCLI and the CLIs?

The ANCCLI amended its articles of association to open it up to all CLIs (with a Board made up of delegates from the CLIs: 4 representatives from each). At its first meeting in February 2005, the Board of the ANCCLI set itself three major objectives:
– first: to give the CLIs a voice in all the matters that concern them (the law on transparency, the law on waste management, and the protection of citizens and the environment);
– second: to represent all the CLIs (or structures of the same type) set up in nuclear installations, by taking in all the interest groups concerned (elected officials, associations, trade unions, chambers of commerce, experts, etc.);
– third: to provide the CLIs with technical and human resources to enable them to perform their tasks: provision of expert resources from the Scientific Committee of the ANCCLI and also, for example, the creation of a web site to act as a portal to disseminate information from the ANCCLI to the CLIs and among the CLIs themselves.

The Act of 2006 establishes the CLIs and a federation still to be defined. Indeed, Local Information Committees (CLIs) have been set up for nuclear installations (INBs). A federation incorporating the two instances (approx. 40 CLIs, of which 28 are members of the ANCCLI, and around 10 CIs) was created in November 2009 as the National Association of Local Information Commissions and Committees.

The ANCCLI will also work to extend the influence of a European body, EUROCLI (created at Dunkerque on 4 October 2006).

At the national as well as the European level, the ANCCLI and the CLIs have raised their concerns and helped to create the conditions for dialogue.

The issue of waste is a problem that interests all countries, both nuclear and non-nuclear, because they all use radioactive elements in medicine and most at least operate research reactors.

The Aarhus Convention (information, participation and access to justice) has been ratified by all the countries of Europe. It is therefore absolutely vital to analyze its implementation in the various countries: the subject of waste cannot be ignored.

And to conclude

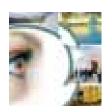
The ANCCLI and its working groups, particularly the GPMDR, will continue to pursue the research priorities (mines, sources, tritium, etc.) defined in the Act of 2006 on waste.

Its involvement in the various bodies (National Plan for the Management of Radioactive Materials and Waste, ASN groups on tritium, High Committee for transparency and information on nuclear safety) will enable it to convey the questions raised by the CLIs and CIs.

The big issue, however, is not participation as such, but the influence of this participation on the decisions taken.

On the matter of waste, the public debate in 2005 exposed the limitations of the exercise:

– reversibility is a given, but what sort? There are still serious disagreements on the definition of reversibility and the argument is far from being resolved. At any rate, the law stipulates



Dismantling of the nuclear power plant EL4 at Brennilis - storage of radioactive waste

100 years, but the question is "When do these famous 100 years begin?";

– storage (always overlooked but often asked about in the debates) will be an unavoidable reality. Indeed, packages of highly radioactive glassware will have to kept in cold storage for 60 to 100 years before being disposed of in a manner still under analysis. There is also a need for storage areas to allow for decay (of tritium, for example) before disposal. And ANDRA proposes to size the surface storage at Bure to enable it to be used for defective packages, hence its fresh importance.

The ANCCLI will therefore address these topics by calling upon the diversity of views of the members of the CLIs and CIs, because this diversity is its strength and its trump card: the tritium symposium and the ACN approach bear ample witness to this. ■

VIEWPOINT HELD BY ASSOCIATIONS AND CONSULTATION BODIES REGARDING WASTE MANAGEMENT

Viewpoint of the "Robin des Bois" environmental protection association on radioactive waste management

by Jacky Bonnemains, president of the "Robin des Bois" (Robin Hood) association for the protection of man and the environment

Aerial view from 12 April 2003 showing the uranium enrichment plant of the German company URENCO in Gronau, Germany

For two decades, the "Robin des Bois" association has advocated each country managing its own hazardous waste, including radioactive waste. The vehemence with which German antinuclear factions are refusing to accept the return of waste from recycling irradiated fuel from German nuclear power plants runs counter to the principles of responsibility and proximity that ecologists claim to espouse.

There are however more logical options than refusing to accept nuclear waste at the end of the cycle, such as blockading the uranium enrichment plant at Gronau which supplies the global nuclear energy industry. The plant at La Hague in this corner of Western Europe is considered an ideal cache when viewed from Lower Saxony. It is true that the list of scrap materials is a long one, including hospital waste, asbestos from the SS Norway, and WEEE that Germany exports all over the place.

"Robin des Bois" is opposed to recycling irradiated fuel, which facilities the proliferation and dispersal of plutonium and other radionuclides into the environment. The association has exposed scandals and scams connected with recycling in fields other than nuclear energy, long concealed by a misleading ecological and systematically positive image.

In this context, it is fortunate that the Bure experimental site in France is also studying the disposal of irradiated fuel without first forcing it into a labyrinth of risky, dangerous and (in every sense) costly recycling.

The proposed European directive on radioactive waste management is intended to accelerate the validation process, particularly for geological disposal, and to bring forward solutions for holding and storage. The good news is that the first draft of the European directive prohibits export to non-European countries. The bad news is that the collection on one site of radioactive waste produced by several countries of the Union could be authorized, thus releasing countries like Germany from the moral and scientific responsibility of managing their own waste. For the moment, certainly, French law forbids the disposal of radioactive waste produced in other countries, but will it stand up in the face of the provisions of the European directive? We shall see. It would be interesting for the minutes of the preliminary working group on this directive, which certainly includes French producers and observers, to be made public. That would help to indicate where they are trying to get to.

"Robin des Bois" reiterates the urgency and the logic behind the prior opening of a disposal facility for radium waste originating from activities dating from the 20th century. Radium's discoverer, Marie Curie, is in the Panthéon, while the waste remains in laboratories, apartments, pharmacies and workshops, with a half-life of 1,600 years; a perfect illustration of the disaster that would result from applying the popularly advanced miracle solution of storing radioactive waste within nuclear power plants.

VIEWPOINT HELD BY ASSOCIATIONS AND CONSULTATION BODIES REGARDING WASTE MANAGEMENT

Radioactive waste: the poisoned legacy of the nuclear industry

by Yannick Rousselet, contact for nuclear issues, Climate/Energy campaign – Greenpeace France

Would you be willing to drive a car without any brakes? Probably not. Yet that is what the nuclear industry has been doing for fifty years: it has been directing atomic energy with its foot on the accelerator, without a proper solution to the poisonous by-products that it generates - radioactive waste.

We are nowhere close to finding a solution for nuclear waste, and we need to abandon this method of producing energy.

> ***"When a problem does not have a solution, you cannot claim to have solved it just because you have made some effort to do so."*** (Hanes Alfven, "Energy and Environment", *Bulletin of the Atomic Scientists*, mai 1972, in Royal Commission on Environmental Pollution, *Nuclear Power and the Environment*, sept. 1976.)

The nuclear industry produces a large quantity of radioactive waste from one end of the nuclear chain to the other: from uranium extraction to enrichment, including the operation of the reactor, the processing of the waste and the decommissioning of the plants. Today, nuclear energy is "sold" to politicians and citizens as an effective means of combating climate change and guaranteeing energy security. However, nuclear energy is a false solution and hence a major obstacle to clean energy in the future.[1] Apart from the problems of safety and security, the nuclear industry faces especial difficulties in relation to the waste that it produces but does not know what to do with. This should prompt it to take its foot off the pedal, but against all expectations this industry carries on faster than ever.

According to the International Atomic Energy Agency (IAEA), the nuclear industry produces a million barrels (or 200,000 m^3) of what it calls "low and intermediate level waste" every year, plus about 50,000 barrels (10,000 m^3) of more hazardous "high level" waste.[2] These figures do not take account of spent nuclear fuel, which is also a type of high-level waste.

It takes no less than 240,000 years for the radioactivity of plutonium-239 to fall to a level that is harmless to humans – a period of time longer than the history of Homo sapiens, who is thought to have appeared on our planet 200,000 years ago. There is no guarantee that these materials can be kept in complete safety for so many years, so it is nonsensical to allow the nuclear industry to go on producing still more waste.

"Tried and tested" disposal options

Over the last fifty years, billions of euros have been spent trying to fix the problem of nuclear waste. So far, every attempt has ended in failure. Some examples:

Immersion of waste: a practise now prohibited

For years, Russia, the United States, France, the United Kingdom, the Netherlands and Japan dumped low and intermediate level waste on the sea bed. But hiding a problem does not make it disappear. The containers are now cracked or corroded. The hazardous substances have spread into the environment and are contaminating marine organisms. Following a 15-year campaign led by Greenpeace, an international treaty was signed in 1993 totally prohibiting the dumping of radioactive waste in the sea.

Disposal in salt mines; water seeps in

In the 1960s, Germany set up an experimental disposal facility in disused salt mines located in the Asse hills in Lower Saxony. A few years ago, it was found that the site had been suffering from water infiltration since 1988. It is estimated that some 12,000 litres of water trickle down the walls of the mine every day. The Asse site, originally intended as a pilot project, was expected to provide a final solution for the disposal of nuclear waste. The Germans now have their doubts as to the viability of layers of salt as a practical alternative. It has just been decided to clear out and recover the 126,000 barrels from the Asse site.

Burying waste under mountains; risk of earthquakes

In 1987, the Yucca Mountain site, around 130 km north of Las Vegas in the USA, was chosen for a long-term repository for radioactive waste generated by American power plants. However, the US Geological Survey (USGS) detected a seismic fault under the site. There are also serious doubts about the long-term movements of underground watercourses which could carry severe pollution into the environment. Because of these problems – and the billions of dollars of budget overruns – the US government stopped financing this project at the beginning of 2010.

Experience from the Manche repository

In France, the Manche disposal facility (CSM), one of the largest nuclear repositories in the world, opened near to

1. In its scenario 'Energy [r]evolution', Greenpeace demonstrates that reliance on energy efficiency and renewable energy sources (wind power, solar energy, biomass, geothermal energy, and tidal and wave power) would help to speed up the implementation of more cost-effective and clean solutions. See: Greenpeace, Energy [r]evolution, a sustainable world energy outlook, 2010. http://www.greenpeace.org/international/Global/international/publications/climate/2010/summary.pdf
2. AIEA, Managing Radioactive Waste, brochures from the IAEA, 1998. www.iaea.org/Publications/Factsheets/English/manradwa.html

In May 2006, Greenpeace activists symbolically dug the top of the nuclear repository site in La Manche in protest against the illegal disposal of foreign waste on French soil.

La Hague in 1969 to receive low-level waste. It closed its doors in 1994. The CSM still holds 520,000 m^3 of radioactive materials from French reactors and from the reprocessing cycle. According to the Turpin commission set up by the government in 1996, the site also holds long-lived and high-level waste... of which the exact inventory remains very poor. This commission considered that the site would "never return to normal" because of the presence of very long-lived waste such as plutonium (some 140 kilos). It has been found that the contamination from the site, especially tritium that has seeped into the groundwater, is not decreasing.

New research, fresh obstacles

Forsmark, Sweden – Olkiluoto, Finland: copper corrosion

Sweden plans to enclose its waste in copper capsules with a cast interior layer, then to bury it 400 to 500 metres down at the end of tunnels bored into the granite. A clay paste called bentonite, which expands on contact with water, will then be injected all around to isolate the capsules completely, fill the cavities and limit the movement of underground water.

This arrangement has been adopted in Finland, and it is being evaluated in Switzerland and the United Kingdom. However, it is already raising serious concerns. Although the copper capsules are supposed to resist corrosion for at least 100,000, research has revealed that signs of degradation could appear after 1,000 years.[3] Another source of worry is the accumulation of hydrogen resulting from the process of corrosion. The high temperatures emanating from the capsules could also compromise the "buffer" function of the clay, while underground watercourses could carry pollutants into the biosphere. Moreover, the Nordic countries are likely to face at least one period of glaciation in the next 100,000 years[4], a situation susceptible to violent earthquakes, possible seepage of water and unpredictable changes in the flows of underground water.

Bure, France – Dessel, Belgium: clay, an unreliable natural barrier

In contrast to Finland and Sweden, which have opted to construct artificial barriers as a precaution against leaks, France and Belgium have turned to a natural barrier - clay. In this case, the waste is enclosed in simple stainless steel containers... which may be eaten away by corrosion much faster than the Swedish capsules. They are then disposed of in layers of clay, which are supposed to isolate the radioactive materials. But is it possible to guarantee that no cracks will appear in the layers of clay, for hundreds of thousands of years to come, and prevent any leakage or infiltration of water that might contaminate the water table?

After waste comes "super-waste"

The EPR produces spent fuel that is seven times more hazardous

Until now, research into nuclear waste has mainly focused on waste produced by reactors already in operation. However, the nuclear industry is developing new "third generation" reactors, designed to enable more efficient use of nuclear fuel. The more energy is extracted from the fuel in the reactor, the longer the fuel has to spend in there. But the longer the period of fission, the more the spent fuel gains in radioactivity and the more dangerous it becomes. This high rate of combustion is meant to increase the amount of electricity produced from a given quantity of fuel and so improve the profits of the plant operators.

3. Hultquist, G. et al., 'Water Corrodes Copper', in Catalysis Letters, Vol. 132, no 3-4, 2009. http://dx.doi.org/10.1007/s10562-009-0113-x
4. Matti Saarnisto, Evaluation report on the Posiva report 2006-5, STUK (Finnish nuclear safety authority), 2008, available on request.

According to recent studies, spent nuclear fuel from the EPR (the French-designed European pressurized water reactor currently under construction in Finland, France and China) will be up to seven times more hazardous per unit of electricity produced. In fact, compared to other existing nuclear reactors[5], the EPR will produce far more long-lived hazardous radioactive isotopes, such as iodine-129.[6] Moreover, because of its increased temperature and fragility, the spent fuel will also be in greater danger of losing its integrity in an accident situation or during storage. In other words, the waste produced by the EPR will not only be more dangerous to health, but the challenges that it raises in technical and risk management terms and in the costs of storage and disposal will also be harder to face.

In 1992, Greenpeace activists blocked the ramp used to dump nuclear waste in the North Atlantic

Disposal: risks to people and the environment

Interactions with man

Once it has been placed in its final repository, nuclear waste needs to be monitored, isolated from any contact with man and protected against natural disasters. The civil and military nuclear waste repositories hold radioactive materials like plutonium and uranium that are among the components of nuclear bombs. A few kilogrammes are enough to make bombs like those used against Japan in 1945. Quite a small quantity of radioactive material held at these sites could be used to build a dirty bomb capable of contaminating an entire city. To address this problem, the arrangements proposed by the nuclear industry stipulate, in the best case, that the repositories should be monitored for 300 years. But there is nothing to guarantee the safety of these sites for the following 239,700 years...

Selection of "nuclear discharges"

Several countries have tried to find an adequate solution for the storage or disposal of their waste. However, when choosing a site, the scientific criteria are often not the deciding factor. Weak resistance from the local population often outweighs optimum geological conditions. *"Here, the permeability of the population strata is more important than that of the underground strata."*

In Finland, more than 100 locations were identified as "potentially adequate". However, following opposition from the local population, the authorities adjusted their selection criteria downwards. Their list then no longer contained only "the best available options", but also "passable solutions" including the Loviisa and Olkiluoto sites. These two towns already had nuclear power stations, so their inhabitants were less hostile to disposing of the waste. The authorities finally opted for Olkiluoto, which has the advantage of being situated in a peninsula which is already home to a repository for low-level waste and two nuclear power plants, with a third under construction.

Interim storage: risk of leaks and terrorist attacks

Some countries, like the Netherlands, have set up facilities for interim storage for up to 100 years, intended to hold nuclear waste on a temporary basis. During this period, the risk of leaks and accidents needs to be addressed. Indeed, this high-level waste, disposed of in great quantities, could cause large-scale contamination if the containers or cells themselves were to deteriorate or fall victim to malicious acts or natural disasters (earthquakes, flooding). While the debate is mainly focused on the final disposal of nuclear waste, most of the spent fuel will remain in temporary storage in less than ideal conditions for the next ten years. So for the time being, the absolute top priority should be to remedy the shortcomings of interim storage.

Treatment: the myth of the nuclear "cycle"

The nuclear industry talks about a "nuclear fuel cycle" and claims that, after use in the power plants, nuclear fuel can be recycled. In the treatment plants, residual uranium and plutonium are separated from the other waste to be "theoretically" re-used in the reactors. In reality, the terms "treatment" and "recycling" are misleading, as a major part of the material recovered is not re-used. For example, the United Kingdom has stocks of 100 tonnes of separated plutonium, and France has over 70 tonnes. Thousands of tonnes of treated uranium have been sent from France to Russia, where 90% of this waste is stored without any future use being planned. Treatment does not help to make the radioactivity of the spent fuel disappear. On the contrary, it causes it to disperse by encouraging discharges into the environment, and by generating a larger volume of low, intermediate and high-level waste. It also preempts the development of other methods of managing the waste. For example, the vitrification of fission products blocks any possibility of transmutation, if this technique were to become effective in the future.

Transport of nuclear waste

Nuclear waste (such as spent nuclear fuel, plutonium and other highly radioactive materials) travels around the planet, often crossing vast densely populated areas. These shipments constitute a substantial danger to the populations and ecosystems that they pass through on their route. In the event of an accident, radioactivity could be spread across many square kilometres at least. Besides, these cargoes could be the target of terrorist attacks. Shipments of nuclear waste regularly run into vehement protests. Citizens criticize the risks being taken, as well as the lack of any solutions to fix the problem. For example, the shipment of nuclear waste taken around once a year from La Hague to Gorleben in Germany brings out tens of thousands of demonstrators. France also sends out and receives tonnes of fissile materials by sea, mainly plutonium and mox from treatment processes. To reach their destination, these

5. Posiva, Environmental Impact Assessment Report, 2008, p. 137. www.posiva.fi/files/519/Posiva_YVA_selostusraportti_en_lukittu.pdf ; Nagra, Estimates of the Instant Release Fraction for UO2 and MOX Fuel at t=0, 2004. www.nagra.ch/g3.cms/s_page/83220/s_name/shopproductdetail1/s_element/142590/s_level/10190/s_product/20408/searchkey/Instant Release Fraction
6. In the event of a leak in a nuclear waste repository, the immediate emissions of iodine-29 from waste with a high rate of combustion from the EPR will be seven times greater than those originating from fuel from the reactors in operation now.

materials pass through the territorial waters of several countries, as well as major marine ecosystems. In Russia, thousands of barrels of depleted uranium are stored on open-air sites in the Urals... and these radioactive materials also come from France. They were transported to Russia until May 2010, when Greenpeace put a stop to these exports. Every week, two or three trucks (each with 150 kilograms of plutonium oxide on board) travel about a thousand kilometres between the plants at La Hague and Marcoule. Stopping the treatment and disposing of the waste on site would avoid the need to transport it and take unnecessary risks.

The cost of nuclear waste

Because we still do not know how nuclear waste can be disposed of in complete safety for thousands of years, it is very difficult to assess the cost precisely. In many countries, nuclear companies are asked to set resources aside for the treatment and disposal of future waste. In several countries, however, these "reserve funds" seem grossly inadequate, and some have been used to make risky investments. For example, following the privatization of British Energy in 1996, the British State had to make up a shortfall of 6.6 billion euros in the company's reserve funds - using taxpayers' money - to enable the decommissioning of the installations and the management of the waste. But this fund covers only part of the total costs of decommissioning and managing the 45 reactors in operation across the Channel. This cost is currently put at some 88 billion euros, and it is likely to increase in the years to come.

We may recall the surprise of the current boss of EDF when he discovered, on a visit to the site of the Bure laboratory, that the estimated cost of this repository was no longer 15 billion but 35 billion euros. Electricity producers and plant operators need to be able to bear the total cost of managing the waste that they have produced.

The position of Greenpeace

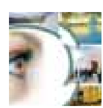
• **We must gradually abandon nuclear power:** if we are to manage the crisis arising from the nuclear waste that we have already produced, the solution is first to stop producing any new waste and to develop clean and energy-efficient sources of electricity. We must block the construction of any new reactors and put an immediate stop to any treatment process.

• **We must store the existing radioactive waste, using the best available technologies:** in order to safeguard our health and prevent radioactivity from contaminating the environment, it must be possible to manage and monitor the stored waste for an indefinite period, with the possibility of recovery. The question of reversibility is crucial.

• **We must prohibit the export of nuclear waste:** it is up to the individual producers to ensure that the nuclear waste that they produce is managed safely, and to avoid having to transport radioactive materials. The "least bad" solution to managing spent fuel is to dispose of it by a dry process at the production sites.

• **We must promote transparency and public participation:** some countries have chosen the location for their nuclear waste repository without consulting the local population, or without exploring alternative solutions. Decisions concerning the management of nuclear waste must be completely transparent, and public consultations must be organized in every case.

• **We must treat the radioactive materials from decommissioning nuclear weapons,** in order to minimize the risk of these hazardous substances being re-used to make a dirty bomb or a nuclear bomb. ■



Contrôle review's articles present the ASN view of the subject covered and gives an opportunity for the various stakeholders concerned to express themselves freely with regard to the law

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p. 1: ASN/V. Bourdon – Vignette:Imagezoom/Artyg, p. 4 : CEA/P. Stroppa, p. 8 : ANDRA, p. 10 : CEA/P. Stroppa, p. 13 : Comet/AIEA, p. 14 à 16 : Noak/Le bar Floréal/IRSN, p. 17 : ANDRA/P. Maurein, p. 19 : ANDRA/Graphix Image p. 21 : COGEMA/P. Lesage, p. 22 : AREVA/JM. Taillat, p. 22 : AREVA/Jezequel Sidney, p. 25 : ASN/DR, p. 26 : ANDRA/ Les films Roger Leenhardt, p. 27 : ASN, p. 29 : ANDRA, p. 32 : ANDRA, E. Gaffard, p. 34 : ANDRA/P. Demail, p. 36 : HCTISN, p. 38-39 : CEA, p. 40 : ASN Division Marseille, p. 40 : CEA/P. Dumas, p. 41 : CEA, p. 42 : CEA/A. Gonin, p. 43 : CEA/P. Stroppa, p. 46 : ASN, p. 47 : COGEMA/ Les films Roger Leenhardt, EDF/DPI/CNPE de Penly, p. 49/50 : CEA/P. Stroppa, p. 52 : ANDRA/P. Maurein, p. 53 : Olivier Seignette/Mikaël Lafontan/IRSN, p. 54 : Noak/Le bar Floréal/IRSN, p. 55 : Olivier Seignette/Mikaël Lafontan/IRSN, p. 57 : ASN/H. Samson, p. 58 : ASN, p. 59 : P. Luchez, p. 60 : ASN, p. 63/64 : P. Luchez, p. 67/68 : CEA, p. 69 : CEA/P. Dumas p. 73/74 : EDF, p. 75-77 : AREVA, p. 80-81 : ANDRA, p. 82 : ANDRA/P. Demail, p. 87 : ANDRA/4 Vents, p. : 88/90 : ANDRA, p. 93 : ANDRA/4 Vents, p. 96-97 : CEA, p. 99-100 : AREVA, p. 104 : Kirstie Hansen/IAEA, p. 106-107 : SKB, p. 111 : Petr Pavlicek/IAEA, p. 113 : CLIS de Bure, p. 114 : ASN, p. 116 : CEA/A. Chezière , p. 118 : EDF / Sautereau Frédéric, p. 119 : DPA/AFP, p. 121-122 : © Pierre Gleizes / Greenpeace

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Notes

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Les dossiers de la revue CONTRÔLE

N°	Titre	Nbre d'ex. (1)
105	La sûreté des réacteurs du futur, le projet EPR (06.1995)	
106	L'organisation du contrôle de la sûreté et de la radioprotection (08.1995)	
107	Les réacteurs en construction – le palier N4 (10.1995)	
108	La crise nucléaire (12.1995)*	épuisé
109	L'activité en 1995 de la DSIN (02.1996)*	épuisé
110	Le retour d'expérience des accidents nucléaires (04.1996)	
111	Les rejets des installations nucléaires (06.1996)*	épuisé
112	Les exercices de crise (08.1996)*	épuisé
113	Déchets radioactifs : les laboratoires souterrains de recherche (10.1996)	
114	La communication sur les incidents nucléaires (12.1996)	
115	L'activité de la DSIN en 1996 (02.1997)	
116	La sûreté du cycle du combustible 1re partie (04.1997)*	épuisé
117	La sûreté du cycle du combustible 2e partie (06.1997)*	épuisé
118	La gestion des déchets très faiblement radioactifs (08.1997)	
119	Le démantèlement des installations nucléaires (10.1997)	
120	Le transport des matières radioactives (12.1997)	
121	L'activité de la DSIN en 1997 (02.1998)	
122	Le contrôle de la construction des chaudières nucléaires (04.1998)	
123	Radioprotection et INB (06.1998)	
124	Les relations internationales bilatérales (08.1998)	
125	25 ans de contrôle de la sûreté nucléaire (11.1998) (épuisé)	
126	La gestion des matières radioactives et son contrôle (12.1998)	
127	La sûreté nucléaire en 1998 (03.1999)	
128	Les réacteurs expérimentaux et de recherche (04.1999)	
129	Le vieillissement des installations nucléaires (06.1999)	
130	Sites contaminés et déchets anciens (08.1999)*	épuisé
131	Les systèmes informatiques dans l'industrie nucléaire (10.1999)	
132	Le retour d'expérience des exercices de crise nucléaire (01.2000)	
133	La sûreté nucléaire en 1999 (03.2000)	
134	La gestion des déchets radioactifs : l'état des recherches début 2000 (04.2000)	
135	Les relations internationales multilatérales (06.2000)	
136	Le risque d'incendie dans les installations nucléaires (09.2000)	
137	Les rejets des installations nucléaires (11.2000)	
138	Le plutonium (01.2001)	
139	Rapport sur la sûreté nucléaire en France en 2000 (03.2001)	
140	L'homme, les organisations et la sûreté (05.2001)	
141	Sûreté nucléaire et transparence (07.2001)	
142	La protection contre les risques externes (09.2001)	
143	Le contrôle de l'utilisation des rayonnements ionisants (11.2001)	
144	L'inspection des installations nucléaires (01.2002)	
145	Rapport sur la sûreté nucléaire en France en 2001 (03.2002)	
146	Transport des matières radioactives (05.2002)	
147	Les réexamens de la sûreté des installations nucléaires (07.2002)	
148	La radioprotection des patients (10.2002)	épuisé
149	La surveillance radiologique de l'environnement (11.2002)	épuisé
150	Sûreté et compétitivité (01.2003)	
151	La sûreté nucléaire et la radioprotection en France en 2002 (03.2003)	
152	Le démantèlement des installations nucléaires : le nouveau panorama (05.2003)	épuisé
153	Le radon : évaluation et gestion du risque (06.2003)	
154	Les enjeux de la maintenance (09.2003)	
155	Les études probabilistes de sûreté (11.2003)	
156	Épidémiologie et rayonnements ionisants (01.2004)	
157	Rapport de l'ASN sur la sûreté nucléaire et la radioprotection en France en 2003 : extraits (03.2004)	
158	La radioprotection des travailleurs (05.2004)	
159	L'harmonisation de la sûreté nucléaire en Europe (07.2004)	
160	La recherche en sûreté nucléaire et en radioprotection (09.2004)	
161	Contamination radioactive : quelles actions pour les sites pollués ? (11.2004)	
162	La sûreté du cycle du combustible (01.2005)	
163	Rapport de l'ASN sur la sûreté nucléaire et la radioprotection en France en 2004 : extraits (03.2005)	
164	Le réacteur EPR (05.2005)	
165	La gestion des déchets radioactifs en France (07.2005)	
166	Contrôler la sûreté nucléaire et la radioprotection (09.2005)	
167	La radioprotection internationale : les acteurs internationaux (12.2005)	
168	Le risque (02.2006)	
169	Rapport de l'ASN sur la sûreté nucléaire et la radioprotection en France en 2005 : extraits (03.2006)	
170	La radioprotection internationale : les autorités nationales de radioprotection (05.2006)	
171	Protéger la population en situation d'urgence (07.2006)	
172	La radioprotection des patients : pour une meilleure prise en compte de la radioprotection des patients dans les pratiques médicales (09.2006)	
173	L'utilisation de sources radioactives dans l'industrie et la recherche (12.2006)	
174	La sûreté des transports des matières radioactives (02.2007)	
175	Rapport de l'ASN sur la sûreté nucléaire et la radioprotection en France en 2006 : extraits (04.2007)	épuisé
176	Les réacteurs expérimentaux et leur contrôle (07.2007)	
177	Les rejets radioactifs en France (11.2007)	
178	Les relations entre l'ASN et les différents acteurs, un an après la loi TSN (01.2008) version sur www.asn.fr	
179	Rapport de l'ASN sur l'état de la sûreté nucléaire et de la radioprotection en France en 2007 : extraits (04.2008)	épuisé
180	La gestion post-accidentelle d'un accident nucléaire (07.2008)	
181	Le démantèlement des installations nucléaires de base (11.2008)	
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