NUCLEAR FUEL CYCLE INSTALLATIONS

1 **PRINCIPAL AREAS OF INSTALLATION REGULATION** 375

1|1 Ensuring the consistency of the cycle

1|2 Controlling licensee organisation

1|3 Promoting operating experience feedback

2 **MAIN INSTALLATIONS IN OPERATION** 377

2|1 The uranium conversion, processing and enrichment plants in operation at Tricastin

2|1|1 AREVA NC TU5 facility and W plant

2|1|2 The uranium isotopes gaseous diffusion separation plant (EURODIF)

2|1|3 The Georges Besse II ultracentrifugation enrichment plant project

2|2 Nuclear fuel fabrication plants in Romans-sur-Isère and Marcoule

2|2|1 The FBFC and CERCA uranium-based fuel fabrication plants

2|2|2 The Mélox uranium and plutonium-based fuel fabrication plant

2|3 AREVA NC reprocessing plants at La Hague

2|3|1 Site description

2|3|2 Plant changes

3 **INSTALLATIONS IN CLOSURE PHASE** 384

3|1 Plutonium technology facility (ATPu) and chemical purification laboratory (LPC) at Cadarache

3|2 Former AREVA NC La Hague installations

3|2|1 Retrieval of legacy waste

3|2|2 Final closure of the UP2 400 plants and the STE 2 installation

3|3 Comurhex uranium hexafluoride preparation plant

4 **OUTLOOK** 387

CHAPTER 13

Fabrication of the fuel and its subsequent reprocessing after it has been used in the nuclear reactors constitute the fuel cycle. However, by convention, the cycle begins with extraction of the uranium ore and ends with disposal of a range of radioactive wastes arising from the spent fuel.

The uranium ore is extracted, then purified and concentrated into "yellow cake" on the mining sites. The solid yellow cake is then converted into uranium hexafluoride gas (UF6) during the conversion operation. This fabrication of the raw material for enrichment is carried out by COMURHEX in Malvési (*Aude département*[1]) and Pierrelatte (Drôme *département*). The installations involved – which are not regulated as basic nuclear installations (BNIs) – use natural uranium whose uranium 235 content is about 0.7%.

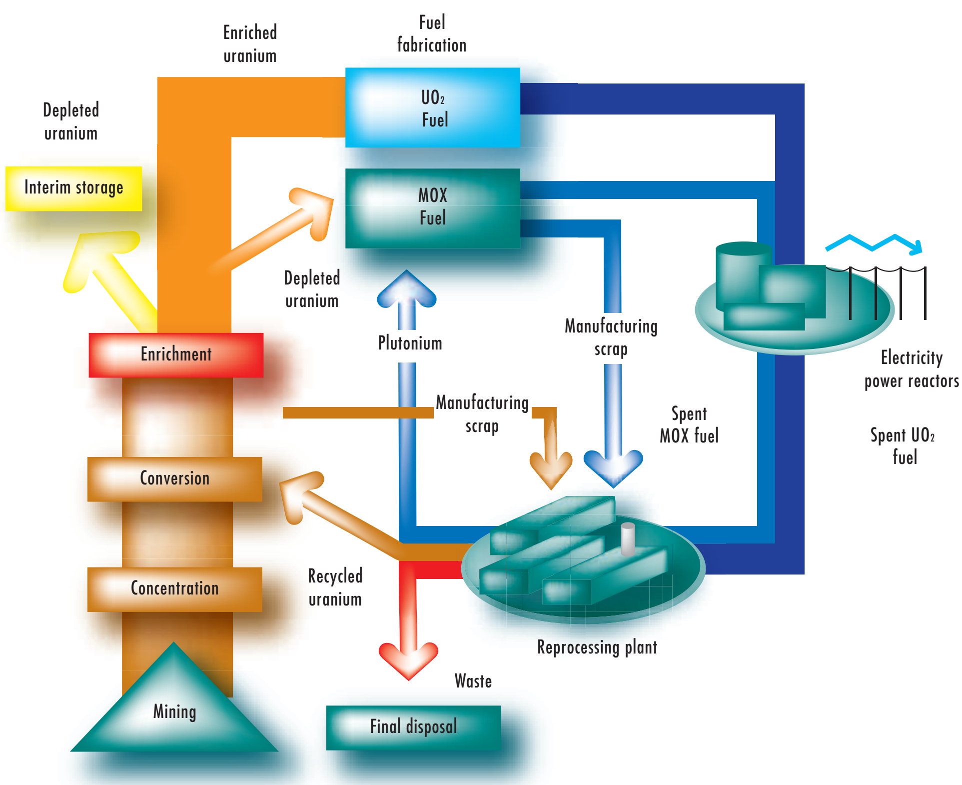
Most of the world's reactors use uranium which is slightly enriched with uranium 235. For example, the pressurised water reactor (PWR) series requires uranium enriched to between 3 and 5% with isotope 235. Raising the isotopic content of uranium 235 from 0.7% to between 3 and 5% is the role of the EURODIF plant in Tricastin, which separates the uranium hexafluoride by means of a twin-stream gaseous diffusion process, with one stream becoming enriched in uranium 235, while the other becomes depleted during the course of the process.

The process used in the FBFC plant at Romans-sur-Isère transforms the enriched uranium hexafluoride into uranium oxide powder. The fuel pellets manufactured with this oxide are clad to make up the fuel rods, which are then combined to form the fuel assemblies. These assemblies are then placed in the reactor core where they release power by fission of the uranium 235 nuclei.

After about three to five years, the spent fuel is removed from the reactor and cooled in a pond, first of all on the plant site and then in the AREVA NC reprocessing plant at La Hague.

In this plant, the uranium and plutonium from the spent fuels are separated from the fission products and the other actinides. The uranium and plutonium are packaged and then stored for subsequent reuse. The radioactive waste produced by these operations is disposed of in a surface repository if low-level, or in storage pending a final disposal solution.

The fuel cycle



1. Administrative region headed by a *Préfet*.

The plutonium resulting from reprocessing is used in the Mélox plant in Marcoule to produce MOX fuel (mixture of uranium and plutonium oxides), which is primarily used in the French 900 MWe PWR reactors.

The main plants involved in the fuel cycle – COMURHEX, AREVA NC Pierrelatte, EURODIF, FBFC, MÉLOX, AREVA NC La Hague – are part of the AREVA group.

The plutonium resulting from reprocessing can be used to manufacture fuel for fast neutron reactors (as was done in the ATPu in Cadarache). Alternatively, in the Marcoule Mélox plant, it can be used to manufacture the MOX fuel (mixture of uranium and plutonium oxides) used in the French 900 MWe PWR reactors.

The main plants involved in the fuel cycle – COMURHEX, AREVA NC Pierrelatte, EURODIF, FBFC, MÉLOX, AREVA NC La Hague – are part of the AREVA group.

Table 1: fuel cycle industry movements(2)

Installation	Origins	Material processed	Tonnage	Produit obtained	Destination	Tonnage (unless otherwise specified)
COMURHEX Pierrelatte	Marcoule INBS	$UO_2(NO_3)_2$ (derived from reprocessed uranium)		U_3O_8	BNIs	6.2
AREVA NC Pierrelatte TU5 facility	**CEA** Marcoule **AREVA NC** La Hague	$UO_2(NO_3)_2$ (derived from reprocessed uranium)	844 9,705	U_3O_8	Storage	255 1,110
AREVA NC Pierrelatte W plant	**URENCO** **EURODIF**	UF_6 (based on depleted uranium	7,235 9,093	U_3O_8	Storage	5,791 7,098
EURODIF Pierrelatte	Converters and **EURODIF** Production Re-enrichment of tails	UF_6 (derived from natural and depleted uranium) UF_6 (based on enriched uranium)	13,707 950	UF_6 (depleted uranium) UF_6 (enriched uranium)	Defluorination and re-enrichment of tails Fuel manufacturers	16,975 2,232
FBFC Romans	**EURODIF** Pierrelatte **TENEX** **URENCO**	UF_6 (based on enriched natural uranium)	799.7	UO_2 (powder) Fuel elements	FBFC, Dessel (Belgium), NFI (Japan), ENUSA (Spain) EDF, Tihange (Belgium), KOEBERG (South Africa)	305.2 413.9 31.1 25.9
	AREVA NC	UF_6 (based on reprocessed uranium)	54.7	UO_2 (powder) Fuel elements	EDF	52.5
MELOX Marcoule	**AREVA NC** Pierrelatte **AREVA NC** La Hague	UO_2 (based on depleted uranium) PuO_2	116.4 10.4	MOX fuel elements	PNPE EDF FBFC-Dessel	122.4
AREVA NC La Hague		Reprocessed spent fuel elements UP3 UP2 800 UP2 400 Spent fuel elements unloaded into pond	 638.515 298.751 – 1,291.80	$UO_2(NO_3)_2$ PuO_2 Vitrified waste packages produced in UP3 Vitrified waste packages produced in UP2 800		852.8 12.6 473 containers 320 containers

(2) The table only deals with the movements inside fuel cycle BNIs, including those in the AREVA NC W plant, which is an ICPE (installation classified on environmental protection grounds) located within the boundary of a BNI.

1 PRINCIPAL AREAS OF INSTALLATION REGULATION

1 | 1 Ensuring the consistency of the cycle

ASN regulates the overall safety-related and regulatory consistency of the industrial choices made with regard to fuel management. The issue of long-term management of spent fuel, mining residues and depleted uranium is examined taking account of the contingencies and uncertainties attached to these industrial choices. In the short and medium terms, ASN particularly aims to anticipate and prevent saturation of the storage capacity of the nuclear power plants, as has been seen in other countries, and to prevent the licensees from using former installations, for which the regulatory and technical licensing requirements are less strict, as an interim storage solution. To do this, ASN relies on the assistance of the Directorate for Energy and Climate (DGEC) at the Ministry for Ecology, Energy, Sustainable Development and Spatial Planning (MEDDAAT), in particular to obtain information concerning materials traffic or the industrial constraints likely to have safety consequences.

EDF was asked to undertake a forward-looking study in cooperation with the fuel cycle companies, presenting elements demonstrating compatibility between changes in fuel characteristics or spent fuel management systems and fuel cycle installation developments.

The data presented by EDF and reviewed to date provide significant clarification of how the fuel cycle operates and the safety issues involved, in particular how changes to fuel management policies may result in changes to the technical and regulatory limits, subject to adequate justification.

In order to maintain an overview of the fuel cycle, the data will have to be periodically updated. For any new fuel management policy, EDF will be required to present a feasibility file specifying and justifying the differences with respect to the “fuel cycle” file previously transmitted.

An overall revision of this file was transmitted in 2008.

Appraisal of all the files submitted by EDF up to the end of 2008 was initiated by ASN and will be carried out jointly, with the support of IRSN, by the Advisory Committees for laboratories and plants, for waste and for transport.

1 | 2 Controlling licensee organisation

Nuclear installation safety is primarily based on the supervision carried out by the licensee itself. In this respect, for each installation, ASN verifies that the organisation and resources deployed by the licensee enable it to assume this responsibility.

The restructuring of the AREVA group has led ASN to exercise increased vigilance in this area, in particular with respect to the minor installations. It is important that the fact of centralising resources, particularly financial resources, enables each nuclear licensee declared as such to continue to fully assume its responsibility as licensee.

In 2007, after observing that initial progress had been made on this subject (coordination set up among the various licensees on the Tricastin site, creation of a decommissioning operations coordination structure for the La Hague site, etc.), and following the SOCATRI incident (see chapter 14, point 3|2|3) ASN also observed that nonetheless this progress had its limits. ASN considers that the organisation of the AREVA installations on the Tricastin site must attach greater importance to safety, particularly when the installations are modified, and should develop a clearer overview of safety issues on the site. ASN therefore informed AREVA that it intended to entrust a review of the organisation of safety and radiation protection in the group’s installations to the Advisory Committee for laboratories and plants. The conclusions of this analysis could be available in 2010.

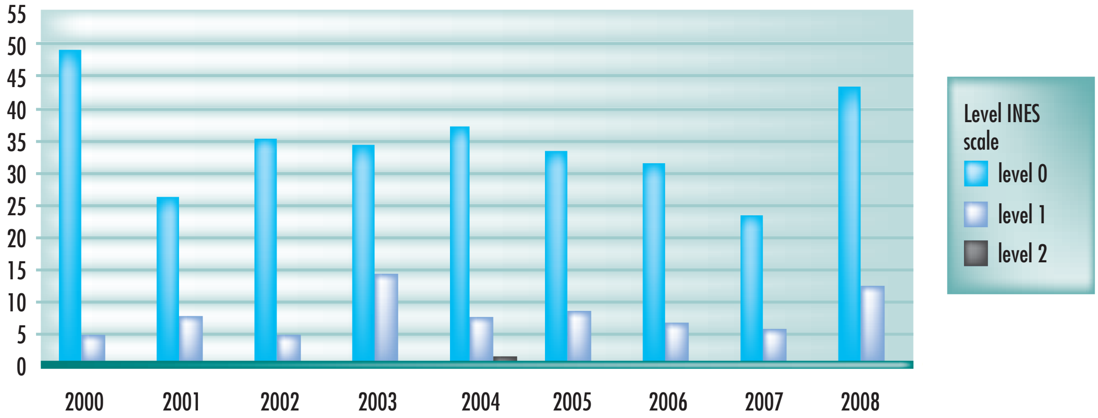
1 | 3 Promoting operating experience feedback

The detection and processing of significant events that have occurred during operation of the installations play a fundamental safety role. The lessons learned from these events lead to new requirements applicable to safety-related items and to new operating rules. Licensees must therefore set up reliable systems for detecting, correcting and learning lessons from all safety-related events.

Graph 1 shows the trend in the number of significant events notified in the fuel cycle installations, rated on the INES scale.

ASN’s monitoring of these events and how they are managed by the licensees in particular enables it to identify:
– events recurring on the same installation;
– events requiring operating feedback to other installations to confirm or invalidate their generic nature, in other words affecting or likely to affect several installations belonging to one or more licensees.

Graph 1: changes in the number of events in fuel cycle installations since 2000



There was a clear rise in the number of significant events notified in 2008 by comparison with 2007. This is partly due to the fact that ASN has taken firm measures to ensure that the licensees concerned are aware that significant event notification criteria must be strictly adhered to.

The most significant event of 2008 was the incident that occurred in the SOCATRI installation on 7 July 2008, leading to a leak of about 75 kg of liquid natural uranium into local watercourses. 2008 was also marked by the incident in the FBFC installation on 17 July 2008 when, while carrying out maintenance work, the licensee discovered that a uranium effluent pipe was leaking into the soil.

During 2008, other events entailing pollution of the environment were also detected on the Tricastin site. At the request of ASN, the licensee is now considering possible modifications to its installations to provide a long-term remedy.

ASN therefore asked the licensees in a letter dated 31 July 2008 to take steps to ensure that these significant events are taken into account, that is:
– to carry out specific checks on the circuits carrying toxic, radioactive, flammable, corrosive or explosive fluids;
– to remedy any anomalies detected during these checks;
– to take steps to draw the attention of the operating and maintenance personnel to the subject of operations which could temporarily compromise the tightness of the circuits or the correct working of the measurement or alarm systems;
– to review the organisation of the shifts, in particular those working at night, and the procedures used to inform the public authorities and local elected officials;
– to make any improvements considered to be useful to improve the safety of operation and of worksites involving several contractors at the same time.

The inspections carried out during 2008 in the Comurhex, AREVA NC and SOCATRI installations on the Tricastin site, showed that when events are actually detected, not enough lessons are learned from them. ASN observed that even if abnormal situations are detected, their analysis does not always provide the licensees with a common view of the safety issues at stake, enabling them to learn all relevant lessons. ASN expects significant improvement in operating experience feedback based on significant events.

2 MAIN INSTALLATIONS IN OPERATION

2|1 The uranium conversion, processing and enrichment plants in operation at Tricastin

To allow production of fuels usable in the French reactors, uranium ore first has to be converted into UF6 and then enriched. These operations take place mainly on the Tricastin site, also known as Pierrelatte.

2|1|1 AREVA NC TU5 facility and W plant

On the Pierrelatte site, AREVA NC operates:

– the TU5 facility (BNI) for conversion of $UO_2(NO_3)_2$, produced by reprocessing spent fuel, into U_3O_8. Although conversion into UF_4 is theoretically possible it cannot at present be done in the installation's current technical configuration;
– the W plant (ICPE within the BNI perimeter) for conversion of depleted UF_6 into U_3O_8, a solid compound which offers safer storage conditions and can be used to produce hydrofluoric acid.

The installation can handle up to 2000 metric tons of uranium per year.

The uranium from reprocessing is partly placed in storage on the AREVA NC Pierrelatte site and partly sent abroad for enrichment.

2|1|2 The uranium isotopes gaseous diffusion separation plant (EURODIF)

The isotope separation process used in the EURODIF plant is based on gaseous diffusion. The plant comprises 1,400 cascaded enrichment modules, split into 70 sets of 20 modules grouped in leak-tight rooms.

View of the TU5 installation on the Tricastin site

View of the EURODIF gaseous diffusion uranium isotopes separation facility on the Tricastin site

Each enrichment module has a compressor for raising the UF_6 gas to the required pressure, an exchanger removing the heat produced by compression and the actual diffuser containing the barriers. These barriers give preferential passage to the uranium isotope 235 contained in the gas, thereby increasing the proportion of this fissile isotope in the UF_6 at each passage.

The UF_6 is introduced in the middle of the cascade, with the enriched product drawn off at one end and the depleted residue at the other.

In the light of the ageing design of this plant, it will be shut down shortly after 2010.

ASN is already monitoring the first studies undertaken by the licensee concerning the shutdown procedures. Given the masses involved – 150,000 tons of steel for the diffusers alone – it is important to anticipate the equipment inventories and characteristics in order to optimise the treatment, disassembly, transport and disposal processes.

At the end of 2008, the licensee also submitted an application for modification of the authorisation decree for the EURODIF plant, in order to increase the maximum quantity of UF_6 present on the BNI.

In 2008, three 48Y or 30B type UF_6 containers were slightly damaged during handling on the Tricastin site. ASN asked EURODIF to carry out a detailed analysis of the causes of these events and will monitor implementation of the appropriate corrective measures in 2009.

2|1|3 The Georges Besse II ultracentrifugation enrichment plant project

The ultracentrifugation process should eventually replace gaseous diffusion. This process, which will be operated by the *société d'enrichissement du Tricastin* (SET), consists in rotating a cylindrical bowl containing uranium hexafluoride (UF_6) at very high speed. The centrifugal force concentrates the heavier molecules (containing uranium 238) on the periphery, while the lighter ones (containing uranium 235) are recovered in the centre.

This process has two key advantages over the gaseous diffusion process currently used by EURODIF: on the one hand, it consumes far less energy (75 MW as opposed to 3,000 MW for equivalent production), and on the other, the design is safer (far less nuclear material in the cascades, plus centrifuges below atmospheric pressure).

Creation of the Georges Besse II plant (GBII), which comprises two separate enrichment facilities (South and North) and support facilities, was authorised by a decree on 27 April 2007.

Prior to the commissioning of the first unit in the installation (called the South unit) the licensee sent ASN the safety case comprising:
– the safety analysis report;
– the general operating rules and the on-site emergency plan;
– the waste study.

The review carried out by ASN and its technical support organisations, IRSN and the Advisory Committee for laboratories and plants, revealed that the low level of UF_6 stocks in the enrichment modules and the operating conditions of the centrifugation process contribute to a high level of control of the risk of radioactive and chemical material dissemination. The licensee also provided satisfactory additional data concerning control of the criticality risks, in response to the questions raised during the review of the preliminary safety analysis report. Finally, the other risks of internal origin (fire and explosion) or external origin (risks linked to the geosphere and to human activities, specific to the actual site) would seem to be well controlled. ASN also considers that the licensee has adopted satisfactory measures to control the risks associated with maintenance work being performed alongside normal operations, owing to the modular design of the plant.

Considering that the provisions presented by the licensee for commissioning of the South unit are satisfactory in terms of safety and radiation protection, ASN decision 2009-DC-0130 of 29 January 2009 authorised commissioning of the installation.

In 2008, SET also submitted an application for a modification to the GBII BNI (168) licensing decree, which will be the subject of a public inquiry.

The arrangement envisaged by SET when the GBII project was launched, was to rely on a support facility called REC II - an integral part of the GBII BNI - and a TE facility operated by AREVA NC. AREVA decided to merge the TE and REC II functions. The resulting facility, incorporated into the GBII project, could provide services for licensees of other installations on the Pierrelatte site and would have shared resources with the GBII North unit, in particular the storage areas for UF_6 containers and the control room. This support installation should enter service by 2011.

EURODIF – group of diffusers

2 | 2 Nuclear fuel fabrication plants in Romans-sur-Isère and Marcoule

After the uranium enrichment stage, the nuclear fuel is manufactured in various installations, depending on the type of reactor for which it is intended. The UF_6 is converted into uranium oxide powder so that after processing it can be made up into fuel rods, themselves subsequently assembled to form fuel assemblies.

This fuel, whether intended for PWRs or for fast or experimental reactors, is manufactured at FBFC in Romans-sur-Isère or MÉLOX in Marcoule, the latter installation being designed for the manufacture of fuels containing plutonium.

2 | 2 | 1 The FBFC and CERCA uranium-based fuel fabrication plants

The two basic nuclear installations located on the Romans-sur-Isère site belong to the CERCA and FBFC companies respectively. These two companies are now an integral part of the AREVA group. In the eyes of the regulations, the FBFC company is the sole nuclear licensee for the site.

The CERCA plant comprises a series of facilities for the manufacture of highly enriched uranium based fuel for experimental reactors. FBFC plant production, consisting of uranium oxide powder or fuel assemblies, is intended solely for light water reactors (PWR or BWR).

FBFC fuel elements fabrication plant

By a decree of 20 March 2006, FBFC was authorised to raise the plant's annual capacity to:
– 1,800 tons for the conversion facility;
– 1,400 tons for the rod, pelletizing and assembly lines.

However, pending the end of the work to renew and modernise the industrial tool, scheduled for 2009, ASN restricted the capacity of the pelletizing lines to 1,000 tons per year.

CERCA plant

The CERCA plant, one of France's oldest nuclear installations, predates the BNI regulations. The Government was therefore simply notified of this installation in 1967.

In order to improve regulation of the activities carried out in the installation, work on drafting the requirements stipulated in Act 2006-686 of 13 June 2006 was started in 2008 and should be completed in 2009.

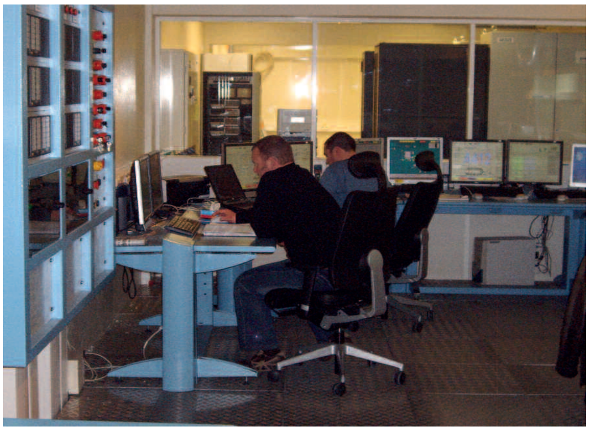
While this is being done, and in accordance with the conclusions of the periodic safety review carried out on this installation in 2006, ASN is particularly vigilant to human factors being considered in the routine operation of the units and handling of the waste produced by the site's activities.

For this installation, 2008 was marked by the occurrence of the significant event of 17 July 2008: during maintenance work, the licensee discovered that a uranium effluent pipe was leaking. The decontamination work on the zone concerned and repair of the installations were completed in November 2008. The licensee submitted an approval application, currently being reviewed, for restart of the effluent transfer installation on 18 November 2008.

2008 was also marked by the occurrence of the significant event of 15 October 2008: during normal surveillance of the site's uranium effluent treatment station, called Neptune, the authorised uranium concentration limit in the discharges sent to the Isère river was found to have been exceeded. This problem led to complete cessation of production on the site for about 3 days, the time needed to discover the origin of the problem and clean the

Example of the modification work already completed: modification of the FBFC fuel elements fabrication plant fitting facility

Conversion control room before modification – August 2007



Conversion control room after modification – November 2008

Example of the modification work already completed: modification of the FBFC fuel elements fabrication plant fitting facility

Fitting facility before modification – November 2007

Fitting facility after modification – October 2008

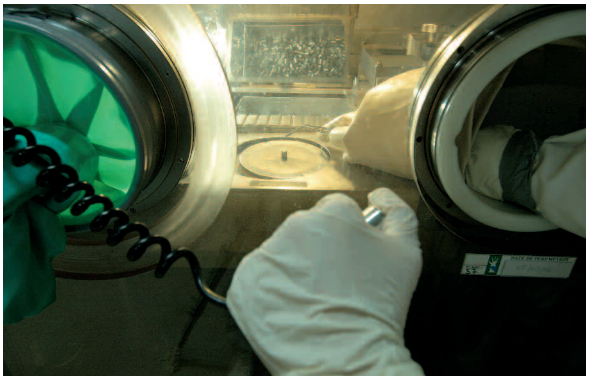
station. In 2007, ASN recorded a rise in the number of deviations with respect to the authorised thresholds for chemical discharges and the licensee agreed to improve the performance of its treatment station. ASN observed that at the end of 2008, the situation had returned to normal, with the number of these deviations being divided by four.

2 | 2 | 2 The Mélox uranium and plutonium-based fuel fabrication plant

The Mélox plant is today the only French nuclear installation producing MOX fuel, consisting of a mixture of uranium and plutonium oxides.

In a decree of 20 March 2007, Mélox was authorised to raise the production capacity of its Marcoule plant to 195 tons of heavy metal.

This increase does not entail any major modification to the industrial tool, so ASN is particularly attentive to the creation of an appropriate and adequate organisation and to strengthening radiation protection optimisation actions.



Dosimetric protection of operator hands using leaded inner gloves. MÉLOX plant in Marcoule (Gard *département*), 2008

2 | 3 AREVA NC reprocessing plants at La Hague

2 | 3 | 1 Site description

The La Hague plant, designed for reprocessing of fuel irradiated in the power reactors (GCR then PWR) is operated by AREVA NC, which replaced CEA as nuclear licensee under the terms of a decree of 9 August 1978.

The various facilities in the UP3, UP2 800 and STE 3 were commissioned from 1986 (reception and storage of spent fuel) to 1994 (vitrification facility), with most of the process facilities becoming active in 1989/1990.

The decrees of 10 January 2003 set the individual capacity of each of the two plants at 1,000 tons per year of metal before passage in the reactor (U or Pu), and limit the total capacity of the two plants to 1,700 tons.

The discharge limits and conditions were revised by the order of 8 January 2007.

Spent fuel reprocessing in the UP2-400 plant has now stopped. The production facilities in the UP2 400 plant have been shut down. (see point 3).

Operations carried out in the plant

The main processing chain of these facilities comprises reception and interim storage installations for spent fuel, plus facilities for shearing and dissolving it, chemical separation of fission products, final purification of the uranium and plutonium and waste treatment.

The first operations to take place in the plant are reception of the transport containers and storage of the spent fuel. Upon arrival at the reprocessing plant, the containers are unloaded, either underwater, in a pond, or dry, in a leak-tight shielded cell. The fuel is then stored in the ponds.

The installations at La Hague

• **BNI 33:**	*UP2 400 plant, the first reprocessing facility*
HAO/North:	*facility for underwater unloading and spent fuel storage;*
HAO/South:	*facility for shearing and dissolving of spent fuel elements;*
HA/DE:	*facility for separation of uranium and plutonium from fission products;*
HAPF/SPF (1 to 3):	*facility for fission product concentration and storage;*
MAU:	*facility for uranium and plutonium separation, uranium purification and storage in the form of uranyl nitrate;*
MAPu:	*facility for purification, conversion to oxide and initial packaging of plutonium oxide;*
LCC:	*product central quality control laboratory.*
• **BNI 38:**	*STE 2 installation: collection, treatment of effluents and storage of precipitation sludges in AT1 facility, prototype installation currently being decommissioned.*
• **BNI 47:**	*Elan II B facility, CEA research installation currently being decommissioned.*
• **BNI 116:**	*UP3 plant*
T0:	*facility for dry unloading of spent fuel elements;*
D and E ponds:	*ponds for storage of spent fuel elements;*
T1:	*facility for shearing of fuel elements, dissolving and clarification of solutions obtained;*
T2:	*separation of uranium, plutonium and fission products, and concentration/interim storage of fission products solutions;*
T3/T5:	*facilities for purification and storage of uranyl nitrate;*
T4:	*facility for purification, conversion to oxide and packaging of plutonium;*
T7:	*facility for vitrification of fission products;*
BSI:	*facility for plutonium oxide storage;*
BC:	*plant control room, reagent distribution facility and process control laboratories;*
ACC:	*hull and end-pieces compacting facilities.*
• **BNI 117:**	*UP2 800 plant*
NPH:	*facility for underwater unloading and storage of spent fuel elements in pond;*
C pond:	*pond for storage of spent fuel elements;*
R1:	*facility for shearing of fuel elements, dissolving and clarification of solutions obtained;*
R2:	*facility for separation of uranium, plutonium and fission products and concentration of fission products solutions;*
R4:	*facility for purification, conversion to oxide and first packaging of plutonium oxide;*
SPF (4, 5, 6):	*facilities for storage of fission products;*
BST1:	*facility for secondary packaging and storage of plutonium oxide;*
R7:	*facility for fission products vitrification.*
• **BNI 118:**	*STE 3 facility: effluent recovery and treatment and storage of bituminised packages.*

After shearing of the rods, the spent fuel is separated from its metal cladding by dissolving in nitric acid. The pieces of cladding, which are insoluble in nitric acid, are removed from the dissolver, rinsed in acid and then water and transferred to a packaging unit. The solutions taken from the dissolver are then clarified by centrifugation.

The separation phase consists of initial separation of the fission products and the transuranic elements from the uranium and plutonium contained in the solutions, and then of the uranium from the plutonium.

After purification, the uranium, in UO_2 $(NO_3)_2$ form, is concentrated and stored. It is intended for conversion into a solid compound (U_3O_8) in the Pierrelatte TU5 installation.

After purification and concentration, the plutonium is precipitated by oxalic acid, dried, calcinated into plutonium oxide, packaged in sealed boxes and placed in storage. The plutonium can be used in the manufacturing of MOX fuel.

Aerial view of the AREVA NC site at La Hague (Manche *département*)

The production operations, from shearing up to the finished products, use chemical processes and generate gaseous and liquid effluents. These operations also generate what is called "structural" waste.

The gaseous effluents are given off mainly during cladding shearing and during the boiling dissolving operation. These discharges are processed by washing in a gas treatment unit. Certain residual radioactive gases, in particular krypton, are checked before being discharged into the atmosphere.

The liquid effluents are processed and generally recycled. Certain radionuclides, such as iodine and less active products are, after checking, sent to the marine discharge pipe. The others are sent to facilities for encapsulation (glass or bitumen).

Solid waste is packaged on the site. Two methods are used: compacting and encapsulation in cement.

The spent fuel solid radioactive waste from French reactors is sent to the low and intermediate level, short-lived waste repository at Soulaines (see point 6|1|2) or stored pending a final disposal solution.

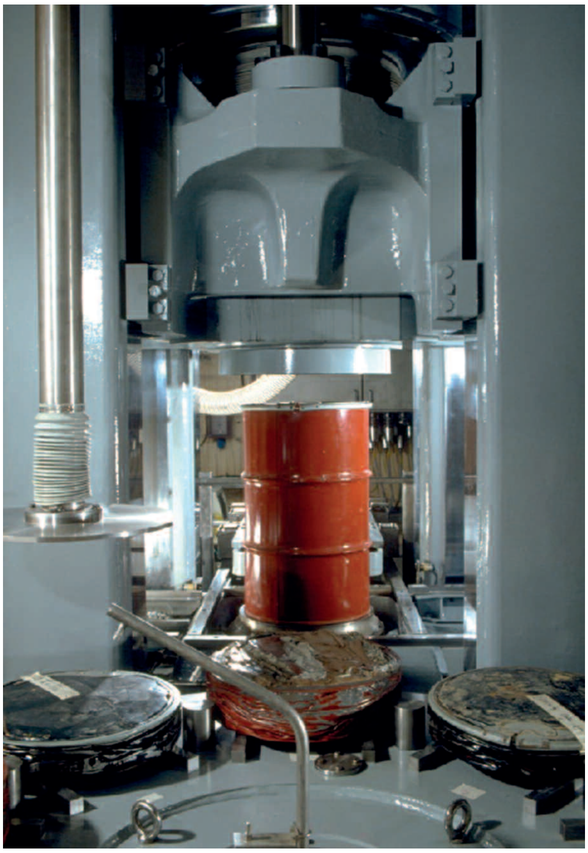
In accordance with Article L. 542-2 of the Environment Code concerning radioactive waste management, radioactive waste from irradiated fuels of foreign origin must be shipped back to its owners. In order to guarantee fair distribution of the waste among its various customers, the licensee proposed an accounting system for monitoring items entering and leaving the La Hague plant. This system was approved by order of the Ministry for Ecology, Energy, Sustainable Development and Spatial Planning on 2 October 2008.

2|3|2 Plant changes

The plant authorised operating framework

The authorisation decrees for the nuclear installations on the La Hague site were revised in 2003, particularly in order to enable changes to be made to the activities on the installations in satisfactory safety and environmental protection conditions and in compliance with the regulations.

Reagents hall in the STE3 effluents treatment station – AREVA NC at La Hague (Manche *département*) – 2006



Low level waste compacting press in the AD2 facility – AREVA NC at La Hague (Manche *département*) – 2007

ASN decisions now authorise broadening of the nature and origin of the materials and substances to be treated, originating in other installations, while remaining within the domain defined by the decrees.

Adaptation of the industrial tool

Environmental protection concerns and new market trends require the licensee to modify its industrial tool.

The cold crucible project

Between 1966 and 1985, the processing of Umo (molybdenum alloy) and MoSnAl (molybdenum, tin, aluminium alloy) type GCR fuels, generated fission product concentrates with a high concentration of molybdenum and phosphorus, that are hard to incorporate into an alumino-borosilicate vitreous matrix. They were stored in tanks in the SPF2 unit, pending possible incorporation into a glass matrix. The solutions stored must now be recovered and packaged. AREVA NC research into a packaging process has led to the development of a vitroceramic type aluminosilicophosphate matrix which would be able to incorporate a large mass of Mo03 while offering good resistance to leaching. This glass will be produced in a cold crucible. The glass poured into this crucible is induction heated, with the metal structure of the crucible being externally cooled, allowing the formation of a protective auto-crucible with high temperatures being obtained at its centre. The first phase of the work was completed between the first half of 2007 and the first half of 2008. Active start-up of the line configured with a cold crucible is scheduled for the end of 2009. The cold crucible will also allow incorporation into a vitreous matrix of the sludges created by processing of the effluents from the rinsing involved in the legacy waste recovery operations.

The 3D project

The “3D” project is a range of operations involving removal from storage, cladding removal and dissolving prior to reprocessing of the non-irradiated MOX fuel materials. Implementation of this project required work in the HAO/North and T4 facilities. In 2008, ASN authorised AREVA NC to process non-irradiated MOX rods from the HANAU and DESSEL plants and the PSI research centre.

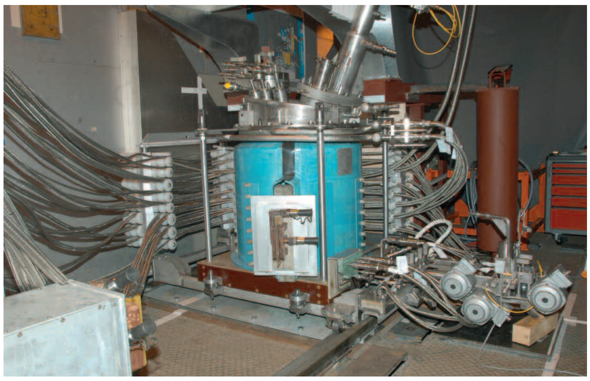
British plutonium

In May 2008, ASN authorised AREVA NC to accept, store and recondition plutonium oxide from the British plant at Sellafield in the UP3-A plant.

This operation is carried out under the “Plutonium Return Agreement”. This agreement was drawn up following the technical difficulties experienced by Sellafield Ltd’s SMP plant, which was unable to meet its MOX fuel delivery contracts. AREVA NC then assisted the English plant by supplying MOX fuel to its European customers. In return, the plutonium advanced by AREVA NC had to be replaced by Sellafield. AREVA NC asked for a part of this plutonium to be sent to La Hague. The first batch of British plutonium landed in France on 21 May 2008. The arrival of the following batches will be dependent on the required changes to the transport conditions (see point 4|3 of chapter 11).

Safety review

Article 29 of Act 2006-686 on Nuclear Transparency and Security requires that every ten years, the licensee conduct a safety review of its Basic Nuclear Installations (BNIs), taking account of the best international practices. This



Cold crucible project – AREVA NC at La Hague (Manche *département*) review should allow an assessment of the compliance of the installation with the rules applicable to it, and an up-to-date evaluation of the risks or drawbacks presented by the installation in terms of security, public health and safety, or protection of nature and the environment, taking particular account of the condition of the installation, experience acquired during the course of operation, new knowledge and the rules applicable to similar installations.

In 2008, ASN presented the safety review for BNI 118, which includes the effluent treatment station (STE3), the solvents mineralisation installation (MDS B) and the sea discharge outfall pipe.

As of 2009, ASN will initiate the periodic safety review for BNI 116 (UP3 plant) and BNI 117 (UP2-800 plant). These reviews will take several years.

3 INSTALLATIONS IN CLOSURE PHASE

3 | 1 Plutonium technology facility (ATPu) and chemical purification laboratory (LPC) at Cadarache

Owing to the fact that the resistance of these facilities to the seismic risk specific to the Cadarache site cannot be demonstrated and their incompatibility with current seismic design rules, AREVA NC halted industrial activities in the ATPu in mid-July 2003. This shutdown commits the ATPu and its support laboratory, the LPC, to a common final shutdown and decommissioning process to be authorised by decree. Against this backdrop, the licensee in 2006 submitted a common file for each of the two installations, pursuant to Article 6 ter of the decree of 11 December 1963, along with the impact assessment required by the Environment Code (see chapter 15, point 2|2|3).

3 | 2 Former AREVA NC La Hague installations

3 | 2 | 1 Retrieval of legacy waste

This point is also covered in chapter 16.

Unlike the new UP2 800 and UP3 plants, most of the waste produced during operation of the first plant, UP2 400, was placed in storage without packaging for disposal. The operations involved in recovering this waste are technically difficult and require the use of considerable resources. The issues linked to the age of the waste, in particular its characterisation prior to any recovery and reprocessing, confirm ASN's approach to the licensees which is to require that for all projects, they assess the corresponding production of waste and plan for processing and packaging as and when the waste is produced.

Subsequent to the November 2005 review of the waste management policy in use at the La Hague establishment by the Advisory Committees for laboratories and plants and for waste, ASN confirmed the need for recovery as early as possible of the sludges stored in the STE 2 silos, the waste in the HAO silo and the waste in the building 130 silo, along with the primarily alpha waste drums stored in building 119 in BNI 38, which offer inadequate safety guarantees.

STE 2 facility sludges

In recent years, processing of STE 2 sludge has been the subject of research and development work, in particular with a view to determining the methods for retrieval and transfer required prior to any packaging. These methods have been determined and efforts are now being concentrated on the packaging itself.

The packaging system today adopted by AREVA NC consists in bituminisation using a process employed in the STE 3 facility. In 2002, AREVA NC was authorised to take samples from one of the silos. The analysis conducted in 2003 by ASN and its technical support organisation, IRSN, showed that major developments were still needed before industrial retrieval of the sludge could take place.

In 2004, the licensee therefore forwarded additional justifications to enable packaging to start as of 2005. It also agreed in 2005 to produce 3,000 drums in the first three years of operation, while continuing to investigate alternative solutions. ASN asked the licensee to validate the chosen scenarios, by carrying out a series of experiments. The feedback from this campaign led the licensee to propose further modifications to the sludge encapsulation process. This was examined by ASN, which did not authorise production of the planned 3,000 drums, in the light of the modifications made. However, in order to gain new insights, ASN in June 2007 asked the licensee to carry out a further series of experiments (3 x 36 drums) in the latest encapsulation conditions defined.

Following on from these experiments and the December 2007 review by the Advisory Committee for laboratories and plants, ASN issued a decision on 2 September 2008, banning the continued bituminisation of STE2 sludges in the STE3 facility.

The licensee is continuing to conduct research into alternative processes. Cement encapsulation and the drying process (DRYPAC) were identified as being technically suitable. However, prior drying of the sludge requires further additional research. In the above-mentioned decision, ASN also asked the licensee to present a preliminary safety assessment report, no later than 1 January 2010, corresponding to the modifications necessary for implementation of an STE2 sludge packaging process, along with the characteristics of the associated waste packages. Recovery of these sludges should be completed no later than 31 December 2030.

HAO silo

The HAO silo contains various waste comprising hulls, end-pieces, fines (dust produced mainly by shearing), resins and technological waste resulting from operation of the HAO facility from 1976 to 1997. Decommissioning of this silo requires prior dismantling of the equipment installed on the silo slab, construction of the recovery cell and qualification of the equipment to be used. Initial dismantling work has already been done.

The detailed preliminary decommissioning studies were reviewed by ASN in 2007. However, the licensee informed ASN at the end of 2008 that recovery of the waste from these silos required further preliminary studies. ASN will ensure that these developments do not significantly delay the beginning of the waste recovery and packaging operations concerned. In this respect, ASN may if necessary impose regulatory requirements.

Silo 130

Following the announcement of postponement of the creation of a graphite waste disposal channel, the licensee stated that its strategy would have to change, but that in any case, the aim of recovering the waste from silo 130 was maintained. The operations will therefore require interim storage of the waste recovered.

The project transmitted by the licensee therefore comprises four phases. The first is to transfer the GCR waste before storage in the D/E EDS facility. The second phase is to drain and treat the water in the silo, in the STE3 installations. The final phases will enable the waste to be recovered from the bottom of the silo, along with the rubble.

In 2008, ASN approved the preliminary preparatory work, in particular installation of the silo waste recovery and evacuation cells.

However, start-up of the first in-situ tests, initially scheduled for 2010, will be delayed, because recovery of the waste from silo 130, as presented by the licensee, requires extensive support work on building 130. At the end of 2008, AREVA stated that it was doing its best to simplify

Storage of waste drums in the ADT facility – AREVA NC at La Hague (Manche *département*)

this project. AREVA claims that the anticipated changes, involving simplification of the repackaging process would avoid having to carry out civil engineering work. This would therefore enable the recovery schedule to be shortened.

Here again, ASN will ensure that these changes do not lead to a significant delay in the start of waste recovery and packaging operations.

At the same time, ASN is reviewing a safety assessment of the consequences and management of a potential loss of containment of this silo.

Old fission product solutions stored in the SPF2 unit in the UP2 400 plant

To package fission products from reprocessing of gas-cooled reactor fuel, in particular containing molybdenum, the licensee has opted for cold crucible vitrification (see point 2|3|2).

The first cold crucible should enter service on the La Hague site in 2011, for packaging of solutions between 2011 and 2017.

Emptying of building 119 in BNI 38

An overall strategy was implemented by the licensee for priority treatment of the existing drums of alpha waste, which are currently stored in building 119.

At the end of 2006, ASN thus authorised the licensee to receive, store in conditions of adequate safety and process in the D/E EB facility in BNI 118, the drums of alpha waste from the French MOX fuel manufacturing plants. This authorisation was supplemented in 2008, to allow the reception, storage in satisfactory conditions of safety, and treatment in the D/E EB facility in BNI 118 of the drums of alpha waste from the plants on the La Hague site.

The treatment capacity will thus be entirely dedicated to building 119, thereby helping to shorten the lifetime of this installation.

A further compacting facility, enabling a larger volume of alpha waste to be handled, will be commissioned in 2013.

3 | 2 | 2 Final closure of the UP2 400 plants and the STE 2 installation

On 30 December 2003, the licensee notified its decision to stop processing spent fuel in the UP2 400 facility as of 1st January 2004. This notification came together with a file presenting the operations scheduled for the final closure (CDE) phase of the various facilities concerned in this plant and the corresponding effluent treatment station. The licensee took the necessary organisational measures, setting up the ORCADE project to manage the final closure operations for the UP2 400 facilities and the legacy waste recovery programmes.

The CDE phase enables the licensee to carry out certain operations to prepare the installation for the decommissioning phase. These operations must be either covered by the operational framework, or be authorised by ASN. In the case of the HAO/South and MAPu facilities, the licensee submitted the safety analysis files for dismantling of certain types of equipment (in particular glove boxes and shears) which are no longer needed. Some of these operations were carried out in 2005 and 2006. For 2008, the licensee asked that equipment dismantling be continued.

ASN also firmly and repeatedly urged AREVA NC to submit the final shutdown and decommissioning file (MAD/DEM) as rapidly as possible for the BNIs corresponding to the UP2 400 plant and the STE 2 installation, i.e. BNIs 33, 38 and 80. The MAD/DEM file for BNI 80 was submitted in February 2008 and the technical options chosen were reviewed by the Advisory Committee for laboratories and plants and covered by an ASN follow-up letter in June 2008. The file was submitted to a public inquiry in November 2008. BNI 80 will however continue to receive fuels that cannot be accepted by the UP3 and UP2 800 plant facilities until such time as the necessary modifications are made to allow reception of this waste in one of the two plants, and will then carry out transfers to the UP3 and UP2 800 ponds.

The final shutdown and decommissioning (MAD/DEM) file for the other BNIs (33, 38 and 47) was submitted in October 2008.

3 | 3 Comurhex uranium hexafluoride preparation plant

The Comurhex plant in Pierrelatte is designed to manufacture uranium hexafluoride.

This production uses natural uranium in the ICPE part of the plant, or reprocessed uranium in the BNI part of the plant. The latter plant consists of two facilities:

– the 2000 facility, which transforms reprocessed uranyl nitrate ($UO_2(NO_3)_2$) into uranium tetrafluoride (UF_4) or uranium oxide (U_3O_8);

– the 2450 facility, which converts the UF_4 (whose uranium 235 content is between 1 and 2.5%) from the 2000 facility into UF_6. This UF_6 will be used to enrich the reprocessed uranium for recycling in the reactor.

In 2008, through its inspections in COMURHEX BNI 105, ASN observed a large number of irregularities concerning the means of preventing chemical or radiological pollution risks. An action plan was requested from the licensee in order to improve the availability of the leak tanks under the hazardous products tanks. It should also be noted that the *préfet*[3] of the Drôme *département* served formal notice on COMURHEX to comply with the requirements of the order authorising that part of the installation classified on environmental protection grounds, following the environmental pollution events.

On 13 October 2008, the licensee notified ASN of final closure of its BNI 105 on 31 December 2008. As of this date, the technical operations preparatory to final shutdown of the installation will be carried out. The licensee of the installation intends to forward the decommissioning plan for this installation to ASN, in accordance with Article 37 of decree 2007-1557 of 2 November 2007, during the first quarter of 2009.

The licensee also points out that the BNI 105 stack, which collects the gaseous effluents from most of the establishment's installations, and some storage areas of BNI 105, will remain in operation beyond the final shutdown date.

The site of the present plant should in the next few years be used for the construction of a new installation classified on environmental protection grounds, comprising the fluorine production and fluorination units. If reprocessed uranium were to be used, this would, as in the past, entail classification of part of these installations as a new basic nuclear installation.

3. In a *département*, representative of the State appointed by the *Président*.

4 OUTLOOK

In 2008, the fuel cycle installations experienced a number of incidents highlighting weaknesses in the organisation of safety and radiation protection in the AREVA group installations. ASN will be particularly vigilant in the coming years, and particularly in 2009, regarding the extent to which lessons are learned from the operating experience feedback from these incidents. It in particular initiated an overall review of the safety and radiation protection organisation within the group as a whole.

ASN also sees in a positive light the changes on the Tricastin site, involving shutdown of the older installations and their replacement by plants offering greater safety. ASN will ensure that these operations and the associated administrative procedures are implemented smoothly.

On the Romans-sur-Isère site, ASN will in 2009 be vigilant in ensuring that the progress already made in terms of safety is confirmed. It in particular expects improved management of the waste areas. It will also be focusing on the actions taken following the safety review of the facilities belonging to the CERCA company.

With regard to the MELOX plant in Marcoule, ASN will remain closely attentive to the organisation and resources implemented to boost the production capacity of the industrial tool and support the changes in the materials used. Control of dosimetry and the ability to take account of human and organisational factors will therefore remain surveillance priorities, even if efforts to improve training have already been observed.

2009 will be an opportunity for ASN to initiate a review of the installation discharge licenses, which should lead to a drop in the authorised limit levels. At the same time, the licensee will initiate the plant's periodic safety review in order to assess the situation with respect to the rules that apply to it and to update its assessment of the corresponding risks.

Finally, even though ASN has not changed its view of the professionalism with which the La Hague site is operated, certain significant events in 2008 have brought to light a relative lack of organisational robustness or shortcomings in the design of certain equipment items. Elsewhere, ASN has recorded progress in the quality of the files forwarded to it by AREVA NC, but considers that efforts are still required, particularly for the periodic safety review of the installations. ASN will also pay particular attention to ensuring licensee compliance with the deadlines for return of foreign waste to the country of origin. With regard to the recovery of legacy waste, ASN's view of the progress of the operations already under way is fairly positive, but is worried about the strategy U-turns by AREVA NC with regard to the recovery and evacuation of the waste from the 130 and HAO silos. There again, ASN will ensure that there is no slippage in the schedule.

Finally, the coming years will see a number of procedures related to review of the applications for decommissioning of the former facilities of the UP2 400 plant. The first facility concerned, the HAO, has already been reviewed by the Advisory Committee for laboratories and plants and a public inquiry concerning this project was organised in the communes neighbouring the site.