CHAPTER 12

EDF'S NUCLEAR POWER PLANTS

This chapter is devoted to pressurised water reactors (PWRs). These reactors, used to produce electricity, lie at the heart of the nuclear industry in France. Many other installations described in the other chapters produce the fuel intended for these plants or reprocess it, store the waste produced by them or review the physical phenomena related to reactor operation and safety. These reactors are all operated by *Electricité de France* (EDF). One particularity in France is the standardisation of plants, with a large number of technically similar reactors, justifying a "generic" presentation in this chapter. However, section 5|1|1 presents an ASN (Nuclear Safety Authority) assessment of each site.

1 GENERAL INFORMATION ABOUT EDF'S NUCLEAR POWER PLANTS

Overall, the 19 French nuclear power plant sites are similar. They each comprise from 2 to 6 PWRs, which in total is 58 reactors. For each of them, the nuclear part was designed and built by Framatome, with EDF acting as industrial architect.

The thirty-four 900 MWe reactors can be split into:

- the CP0 plant series, comprising the 2 Fessenheim reactors and 4 Bugey reactors (reactors 2 to 5),
- the CPY series, comprising the other 900 MWe reactors, subdivided into CP1 (18 reactors at Dampierre, Gravelines, le Blayais and Tricastin) and CP2 (10 reactors at Chinon, Cruas and Saint-Laurent-des-Eaux).

The twenty 1300 MWe reactors comprise:

- the P4 series, comprising the eight reactors at Paluel, Flamanville and Saint-Alban,
- the P'4 series, comprising the twelve most recent 1300 MWe reactors at Belleville, Cattenom, Golfech, Nogent-sur-Seine and Penly.

Finally, the N4 series comprises four 1450 MWe reactors, two on the Chooz site and two on the Civaux site.

Despite the overall standardisation of the French nuclear power reactors, certain technological innovations were introduced as design and construction of the plants proceeded.

The CPY series differs from the Bugey and Fessenheim reactors in building design and the addition of an intermediate cooling system between that used for containment spraying in the event of an accident and that containing river water, along with more flexible operation.

The design of the 1300 MWe reactor systems, core protection devices and plant buildings differs considerably from CPY series provisions. The power increase means a primary system with four steam generators, so that the cooling capacity is greater than for the 900 MWe reactors equipped with three steam generators. Moreover, the reactor containment consists of a double concrete-walled structure, instead of the single wall with steel liner design adopted for the 900 MWe series.

The P'4 series differs slightly from the P4 series, notably with regard to the fuel building and primary and secondary piping.

Finally, the N4 series differs from the previous reactors in the design of the more compact steam generators and of the primary pumps and in the computerised instrumentation and control system.

Location of operating nuclear power plants in France

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Description of a nuclear power plant

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General description of a pressurised water reactor

In passing heat from a “hot source” to a “heat sink”, all thermal electric power plants produce mechanical energy, that they then transform into electricity. Conventional plants use the heat given off by the combustion of fossil fuels (fuel oil, coal, gas) while nuclear plants utilise the heat arising from the fission of uranium or plutonium atoms. This heat produces steam which is then expanded in a turbine to drive a generator to produce 3-phase electric current at 400,000 Volts. After expansion, the steam passes through a condenser where it is cooled on contact with tubes circulating cold water taken from the sea, a river or an atmospheric cooling system.

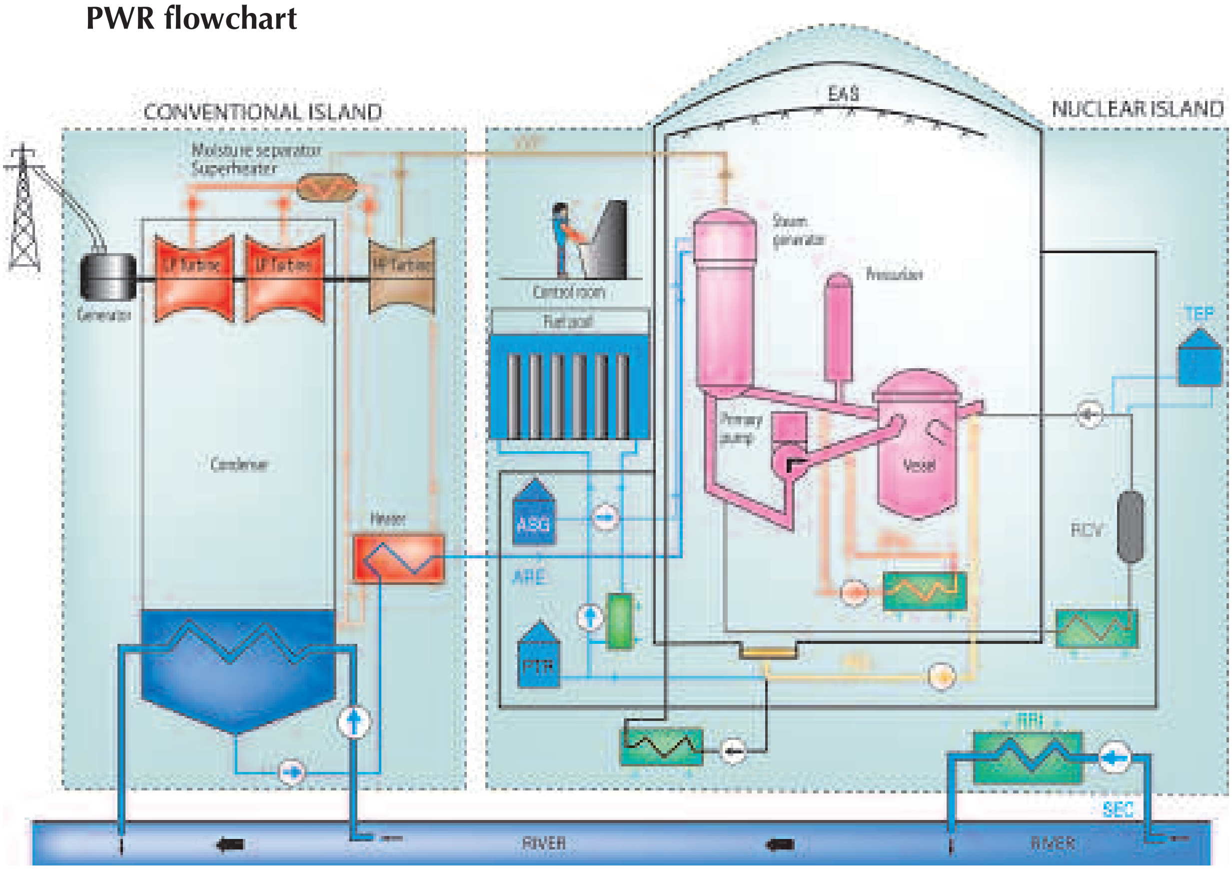
Each reactor comprises a nuclear island, a conventional island, water intake and discharge infrastructures and possibly a cooling tower.

The nuclear island mainly consists of the nuclear steam supply system comprising the primary system and the systems designed for reactor operation and safety: the chemical and volume control, residual heat removal, safety injection, containment sprinkling, steam generators feedwater, electrical, I&C and reactor protection systems. Various "support" function systems are also associated with the nuclear steam supply system: primary waste treatment, boron recovery, feedwater, ventilation and air-conditioning, backup electrical power (diesel generating sets). The nuclear island also comprises the systems removing steam to the conventional island as well as the building housing the spent fuel interim storage pit.

The conventional island comprises among others the turbine, the AC generator and the condenser. Some of this equipment contributes to reactor safety.

The secondary systems belong partly to the nuclear island and partly to the conventional island.

PWR flowchart



ABBREVIATIONS USED IN THE PWR BLOCK DIAGRAM

ARE	steam generator feedwater flow control system
ASG	steam generator auxiliary feedwater system
EAS	containment spray system
PTR	spent fuel pit cooling and treatment system
RCV	chemical and volume control system
RIS	safety injection system
RRA	residual heat removal system
RRI	component cooling system
SEC	essential service water system
TEP	boron recycling system
VVP	main steam system
LP Turbine	low-pressure turbine
HP Turbine	high-pressure turbine

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Core, fuel and fuel management

The reactor core consists of rods containing uranium oxide pellets or mixed uranium and plutonium oxide pellets (MOX fuel), located in fuel assemblies, contained in a steel vessel. When fissioned, the uranium nuclei emit neutrons which, in turn, produce further fissions: this is known as the chain reaction. These nuclear fissions release a large amount of energy in the form of heat. The primary water enters the core from below at a temperature of about 285 °C, flows up along the fuel rods and exits at the top at a temperature of about 320 °C.

At the beginning of an operating cycle, the core represents a considerable reserve of energy, which gradually decreases during the cycle as the fissile nuclei disappear. The chain reaction, and hence the reactor power, is controlled by:

- control rod cluster assemblies which penetrate the core and contain elements which capture the neutrons. These enable the reactor to be started and stopped and its power level to be adjusted to the quantity of electricity to be produced. Falling of the clusters under the effect of gravity triggers automatic reactor trip;
- varying the boron (also an absorber of neutrons) content in the primary system water. The high initial reactivity is offset by the boron - in the form of boric acid - dissolved in the primary system water, since boron has neutron absorbing properties. Its concentration in the water is adjusted during the cycle according to the gradual depletion of the fissile material in the fuel.

The operating cycle ends when the boron concentration approaches zero. An extension is however possible, if the temperature and possibly the power level are brought below their nominal values. At the end of the campaign, the reactor core is unloaded for renewal of part of the fuel.

EDF uses two types of fuels in its pressurised water reactors:

- uranium oxide (UO2) fuel enriched with U-235. Most of this fuel is manufactured by FBFC, a subsidiary of Areva. However, with a view to diversifying its supplies EDF has, since 1980, been obtaining fuel from several foreign fuel manufacturers. Initial U-235 uranium enrichment for UO2 fuel using natural uranium is limited to 4.2%;
- fuels made from a mixture of plutonium and depleted uranium oxides (MOX). MOX fuel is produced by the MELOX plant that belongs to Areva and is located in the town of Marcoule. An initial plutonium content, limited by regulation to an average of 7.08% per fuel assembly, provides an energy equivalence with 3.25% U-235 enriched UO2 fuel. This fuel can be used in the CP1 and CP2 series 900 MWe reactors where provision is made in the authorisation decrees for MOX fuelling. Twenty reactors out of twenty-eight CP1/CP2 series use MOX fuel. In 2006, EDF applied for authorisation to introduce MOX fuel into a further 4 reactors, Le Blayais 3 and 4 and Gravelines 5 and 6, which required a revision of the authorisation decrees for these installations.

Fuel management is different in the various reactor series. It can in particular be characterised by:

- the nature of the fuel used and its initial fissile content;
- the maximum degree of fuel depletion at removal from the reactor, characterising the quantity of energy extracted per ton of material (expressed in GWd/t);
- the length of the burnup cycle (generally given in months),
- the number of new fuel assemblies loaded at each reactor refuelling outage (generally 1/3 or 1/4 of the total number of assemblies);
- the reactor operating mode, with or without major power variation, characterising the stresses to which the fuel is subjected.

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Primary and secondary systems

The primary system and the secondary systems are used to transport the energy given off by the core in the form of heat to the turbine generator set which produces electricity, without the water in contact with the core ever leaving the containment.

The primary system extracts the heat released in the core by circulating pressurised water, known as the primary water, in the cooling loops (3 loops for a 900 MWe reactor, 4 loops for a 1,300 MWe or 1,450 MWe reactor). Each loop, connected to the reactor vessel containing the core, comprises a circulating, or primary pump, and a steam generator. The primary water, heated to more than 300 °C, is kept at a pressure of 155 bar by the pressuriser, to prevent it boiling. The entire primary system is located inside the containment.

The primary water system transfers heat to the water in a secondary system via the steam generators. The steam generators contain thousands of tubes through which the primary water circulates. These tubes are immersed in the water of the secondary system and boil it, without ever coming into contact with it.

Each secondary system primarily consists of a closed loop through which water runs in liquid form in one part and as steam in another part. The steam produced in the steam generators is partly expanded in a high-pressure turbine and then passes through superheater separators before final expansion in the low-pressure turbines, from which it is then routed to the condenser. The condensed water is sent back to the steam generators by the extraction pumps relayed by feed pumps through low and high pressure reheaters.

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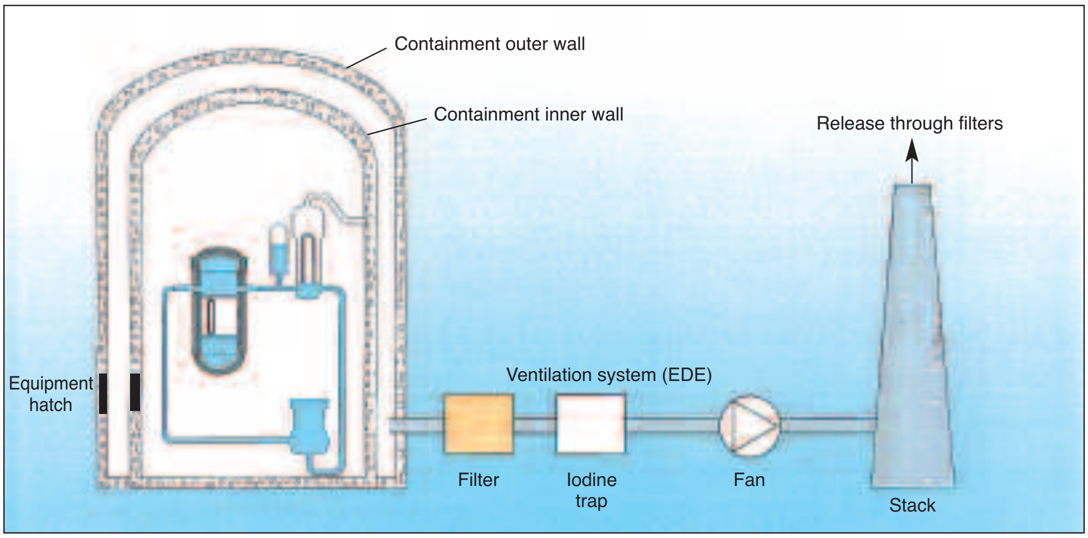
Reactor containment building

The PWR containment building has two functions:
- protection of the reactor against external hazards;
- confinement, thereby protecting the public and the environment against radioactive products likely to be dispersed outside the primary system in the event of an accident. The containments are therefore designed to withstand the pressure and temperature that could be reached in an accident situation, and offer sufficient leaktightness in such conditions.



Block diagram of a 1300 MWe PWR containment building

There are two types of PWR containments:
- 900 MWe type containments, which consist of a single pre-stressed concrete wall. This wall provides mechanical resistance to the most severe design accident pressure and structural integrity against external hazards. Leaktightness is assured by a thin metal liner on the inside of the concrete wall;
- the 1,300 MWe and 1,450 MWe PWR containments, comprising two walls, an inner wall made of pre-stressed concrete and an outer wall made of reinforced concrete. Leaktightness is provided by the inner wall and the ventilation system (EDE) which, in the annular space between the walls, collects any radioactive fluids and fission products that could result from an accident inside the containment. Resistance to external hazards is mainly provided by the outer wall.

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The main auxiliary and safeguard systems

The residual heat removal system (RRA) functions during normal reactor outages to remove the heat from the primary system and the after-power from the fuel and then to keep the primary system water at a low temperature as long as there is fuel in the core. After the chain reaction stops, the reactor core continues to produce heat, which must be removed to avoid damaging the fuel. The RRA system is also used to drain the reactor cavity after refuelling.

While the nuclear steam supply system (NSSS) is functioning, the reactor chemical and volume control system (RCV) is used to control reactivity by regulating the boron concentration in the primary coolant and adjusting the mass of water in the primary system according to temperature variations. The RCV also enables the quality of the primary system water to be maintained, reducing the amount of corrosion and fission products it contains by injecting chemicals (corrosion inhibitors for instance). Finally, this system carries out injection into the reactor coolant pump set seals.

The purpose of the safeguard systems is to control incidents and accidents and mitigate their consequences. This primarily concerns the safety injection system (RIS), the reactor building containment spray system (EAS) and the steam generator auxiliary feedwater system (ASG).

The RIS system injects borated water into the reactor core in the event of an accident in order to smother the nuclear reaction and remove the after-power. It comprises passive pressurised accumulators and various pumps with flow rates and release pressures for different types of accident situations. In the event of an accident, these pumps first of all intake water from a 2000 m^3 tank known as the PTR. When the tank is empty, they are then connected to the reactor building sumps, where the EAS spray water is collected, together with any water that has escaped from the primary system in the event of a leak on this system.

In the event of an accident leading to a pressure and temperature rise in the reactor building, the EAS system sprays water containing additional soda, in order to restore acceptable ambient conditions, protect the integrity of the containment and to flush onto the floor any radioactive aerosols in the air.

The ASG system is used to maintain the secondary water level in the steam generators and thereby cool the primary system water if the normal feedwater flow control system (ARE) becomes unavailable. It is also used in normal operation and during reactor shutdown and restart phases.

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Other systems

The systems necessary for reactor operation and important to its safety also include:
- the component cooling system (RRI), which cools a number of nuclear equipment items and operates in a closed loop between the auxiliary and safeguard systems and the systems carrying water pumped from the river or the sea;

- the essential service water system (SEC), which uses the heat sink (sea or river) to cool the RRI system;
- the reactor cavity and spent fuel pit cooling and treatment system, used notably to remove after-power from irradiated fuel elements stored in the spent fuel pit;
- the ventilation systems, which play a vital role in containing radioactive materials by depressurising the premises and filtering all discharges;
- the fire-fighting water systems.

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Operation of a nuclear power plant

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EDF organisational structures

Within the EDF Engineering and Production Branch, created in 2004, a difference is made between the function of a licensee (operator) and that of an investing owner. Whereas the owner is responsible for the development and long-term exploitation of its asset as well as for its dismantling once operations are completed, the operator is in charge of the short and medium term performance of the production plants and of safety, radiation protection and environmental issues on daily basis.

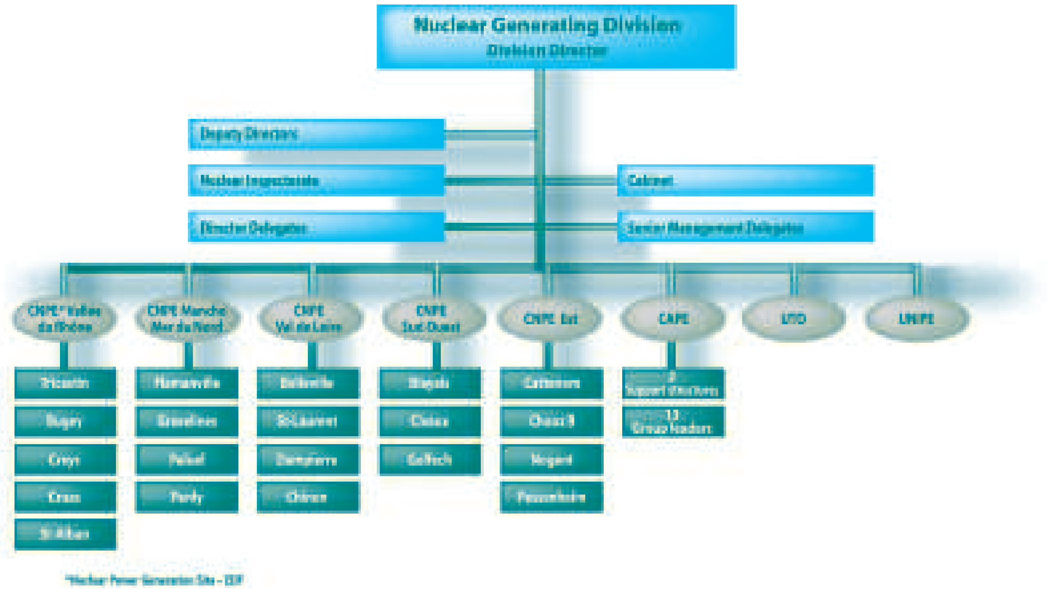
The responsibility of the operator is assumed by the Nuclear Generating Division (DPN). Its duties include day to day operation of the nuclear power plants, including safety, radiation protection and security, along with availability and costs. The Director of the DPN has authority over the nuclear power plant directors and also has at his disposal Head Office departments, comprising expert assessment and technical support services responsible for defining DPN policy and participating in the improvement of plant operation.

Within the DPN, the operating plant support centre (CAPE) is required to provide the plants with help in attaining their safety and performance targets and to help the DPN with plant oversight and monitoring the implementation of technical decisions. This unit offers expertise in the nuclear energy production areas, including safety, environment, maintenance, process engineering, risk prevention and radiation protection. The national engineering unit for operating plants (UNIPE) performs national engineering tasks concerning technical and documentary upgrades, reactor fuel management, and the national emergency response procedures. In particular, its duties are to implement modifications to the installations decided on at a national level and to produce generic operating and maintenance documents. For all the plants, the Operational Technical Unit (UTO) works on generic maintenance, subcontracting and purchasing policies. Finally, the IN (Nuclear Inspection) teams, on behalf of the DPN authorities, carry out verification assignments on the entire division.

In 2006, EDF decided to modify the organisation of engineering for the nuclear power plants in operation. The changes examined concern incorporation of changes and the production of operating documentation. These changes are seen as being an attempt to simplify processes and to ensure greater accountability from the various entities: the sites for the changes that concern them: the designer for the project management aspects delegated to it and for incorporating the operational impact of hardware and documentary modifications and operational engineering for its site support and policy drafting role. These changes will be deployed in 2007.

Within the nuclear power plants, the departments are organised according to professional fields, for performance of safety and radiation protection, production and maintenance functions. Cross-functional project teams are set up for specific activities such as unit outages. The production and maintenance activities can also call on an engineering department.

The roles of owner and designer lie with the Nuclear Engineering Division (DIN). In this respect, DIN is responsible for the facilities design reference framework. It performs engineering activities



EDF's Nuclear Production Division organisation

about the future issues, in other words, studies, draft projects and long-term upgrade projects for the facilities which go beyond the natural scope of the licensee's work. Finally it has oversight for projects designed to maintain the assets, primarily concerning design aspects, in particular the periodic safety reviews.

Among DIN's engineering centres, the design department for thermal and nuclear projects (SEPTEN) is responsible for upstream studies and draft projects. The National Centre for Nuclear Equipment (CNEN) is more particularly responsible for equipment design and modification in the nuclear island of the N4 plant series and the EPR (European Pressurized water Reactor) project. The Engineering Centre for Operating Plants (CIPN) works on the nuclear islands for the 900 and 1300 MWe plant series. The National Centre for Electricity Production Equipment (CNEPE) deals with the conventional islands of all the plants. The dismantling and waste management activities are handled by the Engineering Centre for Dismantling and Related Environmental Issues (CIDEN). Finally, the Production and Operation appraisal and inspection centre (CEIDRE) is particularly responsible for in-service inspection of equipment and for conducting appraisals.

Within the framework of its regulatory activities at the national level, the Nuclear Safety Authority (ASN) deals mainly with DPN. ASN's contacts are the head office departments with regard to generic matters, in other words those that concern some or all of the plant reactors; ASN deals directly with the management of each plant for questions specifically concerning the safety of reactors in it. As regards equipment design and study documents, they are discussed in the first place with DIN. Those concerning fuel and fuel management are also discussed with a third division which has more specific responsibility for these questions, the Nuclear Fuel Division.

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Operating documents

Day to day operation of the nuclear power plants relies on a set of documents. Those concerning safety are given particularly close attention by ASN.

First among these documents are the general operating rules (RGE) which present the provisions implemented during operation of the reactors. They supplement the safety report which mainly deals with the steps taken at the design of the reactor, and translate the conclusions of the safety studies into operating rules.

The RGE comprises several chapters, among which those having particular safety implications are carefully reviewed by ASN.

Chapter III describes the "Technical Operating Specifications" (STE), which specify the reactor's normal operating range and in particular the allowable range for the operating parameters (pressure, temperature, neutron flux, etc.). The STEs specify the operating steps to be taken if these limits are exceeded. The STEs also define the equipment required according to the status of the reactor and state what to do in the event of a malfunction or failure of one of these equipment items.

Chapter VI comprises operating procedures applicable in an incident or accident situation. It stipulates the reactor operations required in these situations in order to maintain or restore safety functions (reactivity control, core cooling, containment of radioactive products) and return the reactor to a safe state.

Chapter IX defines the routine test and inspection programme for safety-related equipment. In order to check the availability of this equipment, and notably the safeguard equipment to be used in the event of an accident, tests are periodically carried out to ensure that these systems are working properly. In the event of an unsatisfactory result, the course of action to be followed is stipulated in the technical operating specifications. This type of situation may sometimes require the licensee to shut down the reactor in order to repair the faulty equipment.

Chapter X finally defines the physical test programme for reactor core loads. It contains the rules defining the programme for core requalification during reactor restart and for core monitoring during reactor operations.

Secondly, there are documents describing the in-service monitoring and maintenance actions required on the equipment. On the basis of the manufacturer's recommendations, EDF defined periodic inspection programmes for the components (or preventive maintenance programmes), based on the knowledge of the potential degradation that could be suffered by the equipment.

In particular for pressurised equipment, this may entail non-destructive testing methods (radiography, ultrasounds, eddy current, dye penetrant, etc.) which are entrusted to specially qualified staff.

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Reactor outages

Owing to the gradual depletion of the fuel, reactors have to be periodically shut down so that the fuel can be renewed. At each outage, one third or one quarter of the fuel assemblies is replaced. The frequency of the outages depends on the fuel management policy.

These outages mean that parts of the installation which are normally closed off during operation become accessible. This is thus an opportunity to verify the condition of the installation by carrying out checks and maintenance as well as any scheduled modifications. Article 14 of the order of 10 November 1999 concerning monitoring of main primary and secondary system operations in particular requires that the licensee carry out periodic checks on these systems.

There are several types of outage:
- simple refuelling outage and partial inspection outage: these outages last a few weeks and are devoted to renewing part of the fuel and conducting a programme of verification and maintenance;
- ten-yearly outage: this outage entails a wide-ranging verification and maintenance programme. This type of outage, which occurs every 10 years, is also an opportunity for the licensee to carry out major operations such as a complete inspection or a hydrotest on the main primary system, a reactor

building containment test or incorporation of design changes decided on in the periodic safety reviews (see point 2|2|2).

These outages are scheduled and prepared by the licensee several months before their scheduled start date, in order to optimise the large number of tasks involved. ASN checks the steps taken by the licensee to guarantee on the one hand safety and radiation protection during the outage, and on the other the safety of operation during the coming cycle(s).

The main points of the check carried out by ASN concern the following:
- during the outage preparation phase, the conformity of the reactor outage programme with the applicable reference system. ASN will give its opinion on this programme;
- during the outage, the handling of any problems encountered, at the regular information sessions and the inspections that may be scheduled, unannounced or in response to an incident;
- at the end of the outage, the state of the reactor and its suitability for return to operation, during the licensee's presentation of the summary of the reactor outage. Following this check, ASN issues the criticality authorisation;
- after criticality, the results of all tests carried out during the outage and after restart.

Replacing a steam generator

2 THE NUCLEAR SAFETY AND RADIATION PROTECTION IMPROVEMENT POLICY

2 | 1

Organisations, safety, competitiveness

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Regulation of organisational and human factors

Regulation of "organisational and human factors" (OHF) in a high-risk system such as a nuclear power plant, implies taking into account anything that could help ensure that human intervention on the system is as effective and safe as possible.

Human intervention, both individual and collective, must be taken into account at the various levels of the organisation.

For too long considered to be the weak link and the error-prone cause of technical system failures, man is an essential component of the safety chain, primarily through his ability to adapt, question and react to unexpected situations. His role in running, supervising and maintaining the facilities is vital.

A number of factors determine human performance and thus the ability of the staff to perform their functions efficiently and safely: characteristics linked to human capabilities and limits, skills, working of the groups and the organisations, operating procedures and instructions, quality of the man-machine interface on the technical equipment in the facility and the working tools, constraints inherent in the working environment.

Including organisational and human factors in safety therefore requires consistent action in a number of areas, such as the training and skills of the staff working in the facilities, the ergonomics of the facilities and the operating documentation, individual and group working methods, organisation and management.

ASN's actions are based on the following general principles:
- the responsibility of the licensee: within the framework of general safety objectives, it is the role of the licensees to define organisational provisions and then adapt them whenever necessary, to take the necessary steps for incorporating human factors into the design and operation of the systems and to ensure adequate training of their staff. ASN where appropriate analyses and approves certain provisions but prescribes no standardised organisational arrangements for nuclear licensees. Similarly, it is up to the licensee to train its staff and assess their ability to perform their duties;
- monitoring; the inspections carried out on licensee sites are frequently an opportunity to examine how the organisations work and enable the extent to which human and organisational aspects are taken into account in nuclear facilities to be assessed;
- experience feedback: analysis of incidents is based on an in-depth search for the causes of events which should enable the licensee to make a more detailed assessment of the lines of defence, particularly human and organisational, and to take appropriate steps to improve them. Feedback of information obtained on the human factors aspects of an event should aim to improve safety and avoid focusing on the failings of the individuals in question or looking for culprits;
- defence in depth: to enable man to play his safety role, human and organisational lines of defence must be set up. These mainly involve defining systematic technical checks on sensitive operations, providing support for the various stakeholders, detecting and dealing with deviations, taking steps and deploying resources to enable those in the field to intervene in the safest possible conditions, and ensuring that those in charge at the various levels of the organisation are familiar with the constraints encountered in the field so that appropriate decisions can be taken.

Control room on the AREVA NC site at La Hague

EDF presented a project to ASN which was aimed at placing human performance at the very heart of safety management. This project comprises two parts:

- ensuring more reliable interventions; this entails giving those involved methods and tools enabling them to “get it right first time”;
- increasing management presence in the field, so that each manager is personally involved in ensuring that the work done by each individual is a success.

Under the impetus of the DPN, this project is currently being deployed in all EDF nuclear power plants. It cannot however take the place of other actions concerning the development of OHF on the site, such as: collecting and analysing early warning signs, in-depth analysis of OHF causes of events and incidents and risk analysis.

Checks carried out by ASN on how OHF were taken into account in nuclear power plants aimed to assess the implementation of these various actions in the field. Inspectors in particular examined the site policy in terms of OHF, the organisation set up for development and the means and resources devoted to it, the action taken in the field of OHF and the extent to which they are considered in incident analyses. The inspections carried out within the nuclear power plants showed the efforts made by EDF to take account of OHF, even if further progress is still needed with regard to actual action on the sites.

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Management of skills and qualifications within EDF

With regard to personnel training and qualification, EDF’s management policy is based on a local system of skills development deployed on each site, comprising members of the various departments, representatives of the human resources departments and training specialists. This policy should lead to the local senior management becoming more closely involved in skills management, in particular through their assessment and identification of requirements. In addition, for training of the operations teams, EDF now has a full-scale simulator on each site.

At the request of ASN, the advisory committee for reactors in 2006 examined the skills management and personnel qualification approach employed by EDF.

Generally speaking, ASN considers that the skills management and qualification system for PWR operating personnel is satisfactory.

ASN considers that EDF has set up a real skills management policy with significant resources, aimed at precisely identifying the necessary skills and building the appropriate professional improvement actions. The management tools developed by EDF (skills reference documents and maps, assessment charts) enable the sites to implement this skills management policy operationally.

ASN also considers that EDF has taken organisational steps to provide effective support for deployment of its approach. The local skills development systems enable production of professional improvement solutions tailored to the needs of the staff. The system of "professional coordinators" established at national level, contributes to distribution of management tools and the promotion of exchanges of good practices between the sites. ASN nonetheless asked EDF to reinforce national level support for local development of skills management with respect to the subcontractor supervisor function.

ASN asked EDF to present a summary of the conditions in which staff are given access to training and the steps taken to make up for the effect of the postponed training in skills that are important for safety and radiation protection. ASN also asked EDF to look at measures to improve the way in which the answers provided actually meet the individual skill needs.

ASN recalled the particular importance it attaches to having EDF continue and reinforce the actions already in progress, in order to ensure that the skills vital to safety continue to be present when the large-scale wave of retirements starts in 2008.

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Monitoring the quality of subcontracted operations

Maintenance of the reactors in the French nuclear power plants is to a large extent subcontracted by EDF to outside companies. This activity, which is highly dependent on the scheduling of nuclear power plant outages, involves about 20,000 people.

Implementing an industrial policy such as this is left to the initiative of the licensee. In application of the order of 10 August 1984 concerning the quality of the design, construction and operation of basic nuclear installations (BNI), ASN is responsible for checking that EDF meets its obligations with respect to the safety of its installations by implementing a quality approach, and in particular checks on the subcontracting conditions.

When subcontractors are called in, ASN monitors the aspects mentioned below, which also constitute the basis for the "progress and sustainable development charter" signed by EDF and the main contractors.

Selection and supervision of the activities performed by the subcontractors

In order to comply with the requirements of the above-mentioned order of 10 August 1984, EDF implemented a system for qualifying its subcontractors, based on an assessment of their technical competence and quality organisation. In addition, EDF is required to monitor its subcontractors' activities or have them monitored and use experience feedback for a continuous assessment of their qualification.

In 2006, ASN carried out inspections on implementation of the overall worksite assistance services (PGAC), which comprise activities such as logistics, scaffolding erection, radiation protection) and the PMI (integrated maintenance services), which comprise all maintenance activities, in particular for operations involved in opening and closure of reactor vessels and tanks. These structures are designed to improve the control and coordination of the activities subcontracted in the power plants.

After observing the problems with PGAC implementation at the beginning of the year and in particular inadequate subcontractor resources, ASN considers that the inspected sites correctly supervised the activities carried out by the subcontracting personnel. It will maintain vigilance concerning the conditions for applying the PGAC to all nuclear power plants.

With regard to the PMI, ASN considers that EDF has to make further progress in surveillance in the field and in giving due consideration to the risks involved in simultaneous activities.

Finally, ASN will remain attentive to the results of the other maintenance services for which EDF is the client.

Performance conditions

On the basis of its inspections, ASN considers that EDF needs to improve the quality of risk analyses and updating of them following the checks carried out by EDF personnel on the worksites and to improve surveillance of effective implementation of compensatory measures appropriate to the risks identified. ASN also considers that EDF must improve its surveillance in the field, particularly concerning compliance with the requirements applicable to subcontractors and the traceability of technical inspections.

Radiation protection and working conditions

In terms of radiation protection for workers involved in outage activities, ASN focused its attention on enforcing the Labour Code through inspections conducted during the reactor outages. ASN was in particular able to check that monitoring of worker exposure to ionising radiation was conducted with an equivalent quality level, regardless of whether the work done was by a person employed by a subcontractor or by the licensee. It nonetheless considers that progress is still needed on radiological cleanness and compliance with the rules for work in a contaminated environment.

The subcontractor market

The decision made by EDF to outsource part of its reactor maintenance work must not create a situation of dependency in which it relinquishes control over the planning or quality of the work done.

Even if EDF has set up an organisation for surveillance of its subcontractor market and supervision of the available resources, ASN maintains a close watch on the subject through its inspections on the sites and in head office, through analysis of the EDF diagnosis and through external audits.

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Safety and competitiveness

Act 2000-108 of 10 February 2000 regarding the modernisation and development of the public electricity service considerably modifies the electricity market in France. Whilst stipulating EDF's public service commitments, the act, which transposes a European directive on the internal electricity market, in particular places EDF in competition for the production and supply of energy to the main customers.

EDF underwent a change of status in 2004, becoming a limited company. At the end of 2005, the company was floated, with the State retaining an 86% stake. The law stipulates that the State must keep at least 70% of the equity and voting rights.

Cost control concerns are now more clearly apparent in the licensee's dialogue with ASN. Technical discussions with EDF have clearly become tougher with regard to economic feasibility aspects, or to the justification for certain requests or certain deadlines, and in the handling of very short-term subjects during unit outages. A broader discussion has begun and is continuing on the potential safety impact of electricity market changes and the new practices implemented or foreseen by the licensee.

To adapt its regulatory work to this new context, ASN is developing tools to ensure advance warning of any drift: economic situation, expenditure trends, workforce management, safety and radiation protection indicators and licensee organisational changes will be the subject of closer attention. As in previous years, ASN in 2006 reviewed the summary forwarded by EDF on these points. The expenditure trends show that EDF is continuing to invest in maintaining the assets and that the R&D effort remains satisfactory. Overall, the 2006 review showed no worrying drift. However in the future, ASN will be keeping a close watch on the consequences of any reorganisation by EDF designed to attain its economic performance targets.

In 2006, ASN also significantly increased its regulation EDF by conducting "safety and competitiveness" reviews. These reviews aim to check how the licensee continues to guarantee a high level of safety in the currently changing context. These reviews looked in particular at the processes involved in making budget choices and how the sites decided between the various options. ASN observed that the "safety and quality" departments in the nuclear power plants are involved in these processes in order to analyse the potential impact on safety of these budget choices.

Another area of work is to set up a more open and responsible dialogue with the licensee about economic issues. One instrument used in this dialogue is the system of analyses offsetting the cost against the safety benefits, so that for a given financial resource level the actions offering the highest safety gains can be chosen.

In 2006, ASN also asked its technical support organisation, the Institute for Radiation Protection and Nuclear Safety (IRSN), to review the EDF safety management system in a competitive context. This analysis will aim to clarify the following points:
- the emphasis actually placed on safety;
- the operational nature of safety;
- the possibility of continuing to improve safety.

This review will be the subject of a meeting by the Advisory Committee for reactors in 2007.

Finally, ASN is developing exchanges with its foreign counterparts, with a view to achieving harmonisation of health requirements, at a time of licensee internationalisation and the advent of a competitive electricity market. The work done within the WENRA association, in which ASN plays an active role, contributes to this.

2 | 1 | 5

Internal authorisations

As part of its nuclear installations safety regulating role, ASN can make certain reactor operations dependent on its prior approval. In certain cases, prior authorisations were imposed on the licensee following significant incidents. However, ASN considers that the prior authorisation system must remain limited to the cases which specifically require it, either because stipulated in the regulations or because of the safety, radiation protection or environmental protection issues. Actually, such a system could encourage the licensee to shift the burden of validating its operations or documents onto ASN and thereby pay less attention to their quality, which runs contrary to the principle of the licensee's responsibility for nuclear safety.

According to experience feedback in recent years, ASN considers that some of the prior authorisation requirements could be lifted, provided that EDF reinforces monitoring of the activities and implements an appropriate supervisory organisation. This concerns:

– lowering the primary system water level to the "low operating range" of the RRA system with core loaded (transient commonly called "mid-loop operation");
– reactor restart after outages without significant maintenance.

Since January 2005, authorisations in these two areas have been issued by the DPN management or the site management, following a review by an independent internal commission comprising the safety and quality managers. EDF also checks the working of these processes and reports on them to ASN.

In 2006, ASN conducted a review in each plant on the subject of internal authorisations. These reviews were an opportunity to check compliance with the new requirements.

2 | 2

Continuous safety improvements

2 | 2 | 1

Anomaly correction

In recent years, a number of anomalies have been detected in EDF nuclear power plants, to a large extent as a result of the systematic conformity checks required by ASN, but also because of the questioning attitude of the licensee, which tracked down these anomalies at its own initiative. ASN requires that those anomalies with potential safety consequences be corrected within a timescale commensurate with their significance.

ASN considers that the checks carried out contribute to maintaining a high level of safety, as it is clear that an installation where no anomaly checks are carried out would only appear to be safe.

Systematic checks: conformity reviews

ASN requires that conformity reviews be conducted as part of the periodic safety reviews. The conformity reviews consist in comparing the state of the facility with the design safety requirements, taking account of changes made since construction, and listing any anomalies. These anomalies can be of various origins: design errors, construction defects, discrepancies introduced during maintenance, deterioration due to ageing and so on.

This review in particular includes a check on the conformity of the steps taken to protect against external hazards, such as extreme weather conditions and earthquakes, and against internal hazards such as high-energy pipe breaks, as well as a check on the ability of equipment to operate in the degraded ambient conditions likely to exist in the event of an accident (known as "qualification for accident conditions"). To this must be added a "programme of additional investigations", the aim of which is to check the parts of the facility which are not covered by maintenance schedules because access to them is too difficult.

The conformity review for the 1300 MWe reactors are part of the periodic safety review associated with the second ten-yearly outages and took place between 1999 and 2003. The conformity review for the 900 MWe reactors as part of the periodic safety review associated with the third ten-yearly outages, will take place from 2007 to 2014.

"Real time" checks

In addition to these systematic anomaly detection processes, the licensee's questioning attitude can also help to detect conformity deviations. The routine inspections carried out in the field, or a critical review of old design studies in the engineering centres can also make a contribution. Several anomalies were discovered in this way and ASN considers EDF's attitude in this area to be positive.

Informing ASN and the public

A specific procedure was set up to inform ASN about the conformity anomalies discovered by EDF. When there is any doubt as to the conformity of an item, EDF notifies ASN and undertakes a process of "characterisation" which aims to determine whether there is a real deviation from the design safety requirements and if so, to specify the equipment affected and assess the consequences of the anomaly for safety. ASN is informed of the characterisation results and a significant safety event declaration is sent out to it as necessary.

The most significant conformity anomalies (INES scale level 1 and higher) are posted on ASN's website.

This procedure guarantees transparency both to ASN but also to the public.

ASN's remediation requirements

ASN reviews the remedial measures proposed by EDF, in particular the lead-times, taking account of the safety consequences of the anomaly.

Any conformity deviation which significantly impairs safety must be corrected rapidly, even if the remedial measures entail a large volume of work. The facility may have to remain shut down until the repairs are made if the risk involved in operating it is considered to be unacceptable and if there are no possible palliative measures. Conversely, repair of a less serious anomaly may be spread over a longer period of time if particular constraints so warrant.

For earthquake resistance anomalies, one factor in assessing the urgency of the repair is the seismic level for which the equipment in question is designed. In cases in which there is only a need to restore a safety margin for equipment items which can already withstand a large-scale earthquake, longer repair lead-times may be granted.

Examples of anomalies currently being handled

– The recirculation sump filters clogging risk

N4 plant series reactor sumps

In the event of a pipe break accident on the primary system inside the reactor building, the safety injection system (RIS) and containment spray system (EAS) are automatically triggered. The purpose of injecting water into the primary system is to cool the nuclear fuel in the reactor core. The purpose of spraying by the EAS system is to bring down the temperature and pressure within the containment. These systems are described in point 1|1|5.

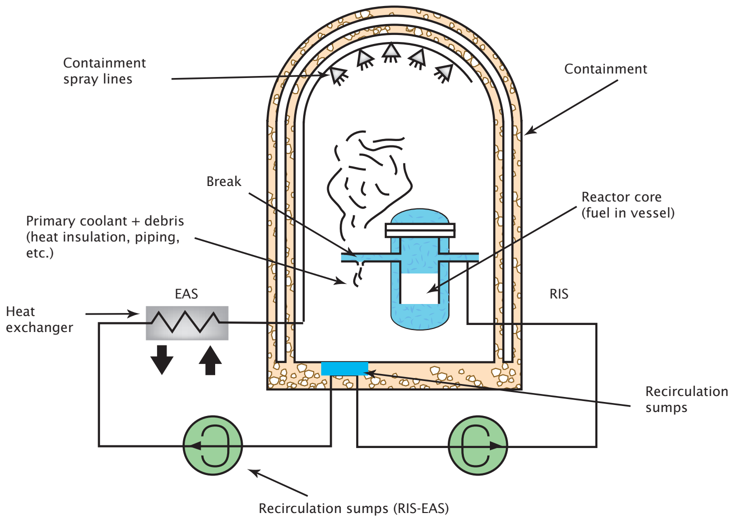
Studies have shown that in certain highly improbable accident situations involving a large-scale break on the primary system, clogging of the sump filters could not be ruled out, but that it could be discounted for less serious breaks. This affected all French nuclear reactors were concerned to various extents, with the older ones apparently being the most prone to this phenomenon, as they offer a smaller filtration surface area. Given its potential impact on installation safety, this anomaly was rated 2 on the INES scale.

To remedy this anomaly, EDF decided to replace the sump filters in order to significantly increase the filtration surface areas.

Having received the opinion of the Advisory Committee for nuclear reactors, which reports to it, ASN considered that additional studies were needed to confirm certain assumptions, but without this standing in the way of the proposed modifications.

Work on this modification began in 2005 on three 900 MWe reactors and continued in 2006. EDF made a commitment to correcting the anomaly before the end of 2009 on all reactors and before the end of 2007 on those reactors most susceptible to the clogging phenomenon.

Furthermore, while reviewing the design reference system for the EPR reactor, ASN asked EDF to take all steps to "practically eliminate" the risk of clogging of the water intakes for the safety injection, containment spraying and corium recovery cooling systems. These provisions underwent a technical review in the summer of 2006, with consultation of the Advisory Committee for nuclear reactors. In compliance with the principle of defence in depth, this review looks at:
- the factors underlying the risk of water intake clogging, in particular the selection of materials used in the reactor building (choice of heat insulation, paints, etc.);
- the countermeasures which, in degraded conditions, prevent clogging of the water intakes (sizing of filter surfaces, possibility of filter cleaning by reverse recirculation of water over the screens).



PWR recirculation function

– Cooling water leak in the turbine hall

On 18 February 2006, a leak occurred at the Nogent-sur-Seine nuclear power plant on the steam cooling system in the non-nuclear part of the installation.

This cooling system uses air cooling towers. The leak occurred at the outlet of a pump returning some of the water intake back to the river.

Cracks in the pump concrete structures led to leakage of the water leaving the cooling towers into the reactors 1 and 2 turbine hall. This led to a decision to shut down reactor 2 and to automatic trip of reactor 1.

The anomaly had no direct consequences for the safety of the two reactors. On 20 April 2006, EDF nonetheless declared a significant safety incident, rated level 1 on the INES scale.

New sumps installed by EDF in 2005

Assessments and various civil engineering work (injection into the cracks, anchoring of the concrete floor, etc.) were carried out.

A programme of systematic reviews is implemented on all 1300 MWe reactors cooled by cooling towers.

2 | 2 | 2

Review of events and feedback from reactor operations

The general process for incorporating experience feedback

Experience feedback is a major source of improvement in terms of safety, radiation protection and the environment. EDF sends ASN declarations of all significant events occurring in the nuclear power plants in service. Criteria have therefore been set for declarations submitted to ASN. Each event is rated by ASN on an international nuclear events severity scale, the INES (International Nuclear Event Scale), which comprises 8 levels from 0 to 7, depending on the severity.

Both locally and nationally, ASN reviews all declared events. For certain events felt to be most important, because of their significance or their recurring nature, ASN carries out a more in-depth analysis.

ASN makes sure that EDF does actually learn the lessons from past events in order to improve safety and radiation protection. At a national level, ASN reviews how EDF deals with the declared events. During reviews in the nuclear power plants, ASN also reviews EDF site organisation and the steps it takes to deal with events and take account of experience feedback.

ASN also ensures that EDF learns lessons from events occurring abroad and which can be transposed to its own nuclear reactors.

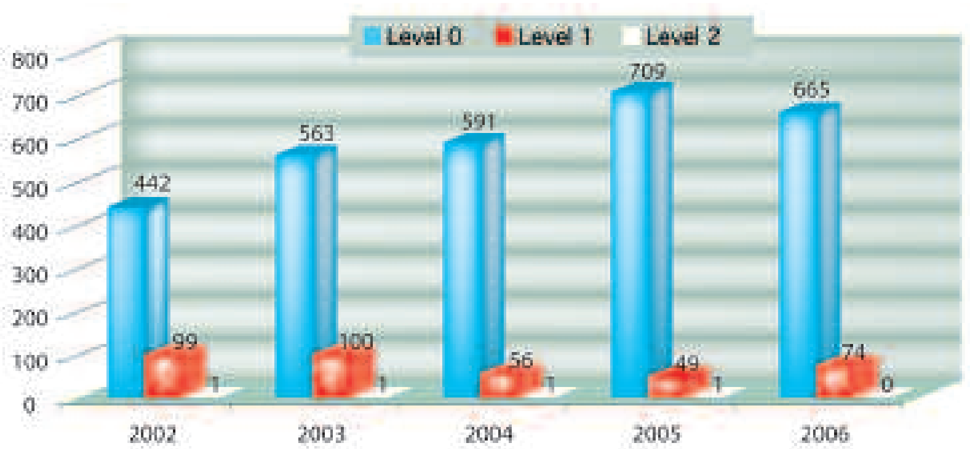
Finally, at the request of ASN, the Advisory Committee for reactors periodically reviews feedback from PWR operations. The next review will cover the period 2003-2005.

Events in 2006

In application of the rules for declaration of safety, radiation protection and environmental incidents, EDF declared 739 significant incidents rated on the INES scale in 2006, 619 of which concerned safety, 111 of which concerned radiation protection and 9 of which were linked to uncontrolled releases of radioactive products into the environment.

The events declared with respect to environmental protection and which concern neither nuclear safety nor radiation protection, are not rated on the INES scale. 18 such events were declared in 2006.

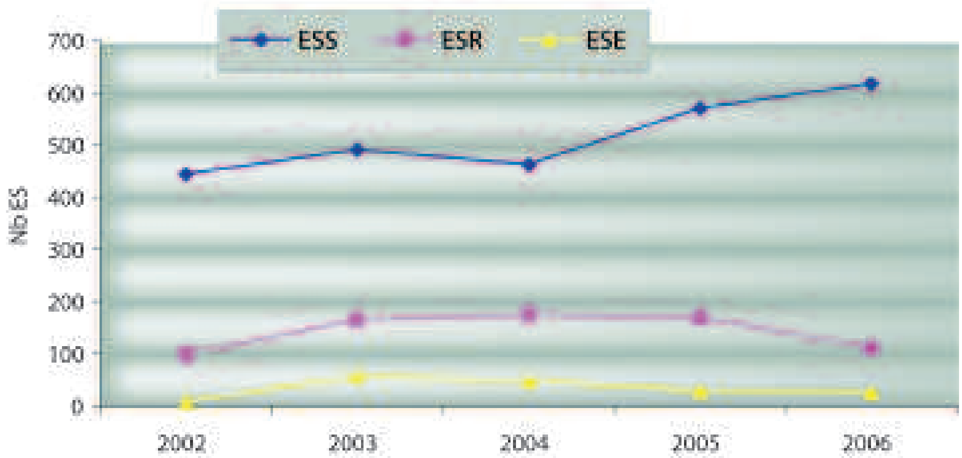
The following graph shows the trends in the number of significant events declared by EDF and rated on the INES scale since 2002.



Trend in the number of classified events in EDF reactors since 2002

The total number of significant events rated in 2006 is slightly down on that for 2005.

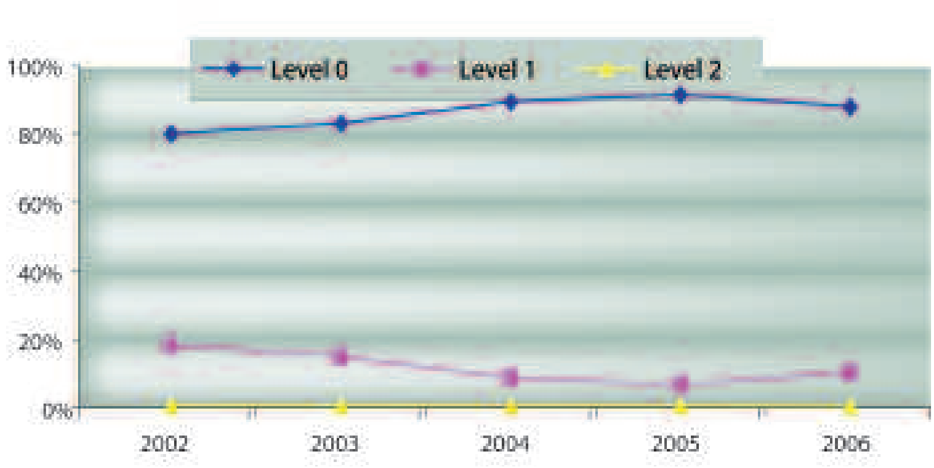
The following graph shows the trends since 2002 in the number of events per area concerned by the declaration: significant safety events (ESS), significant radiation protection events (ESR), significant environmental events (ESE).



Trend in the number of events per field since 2002

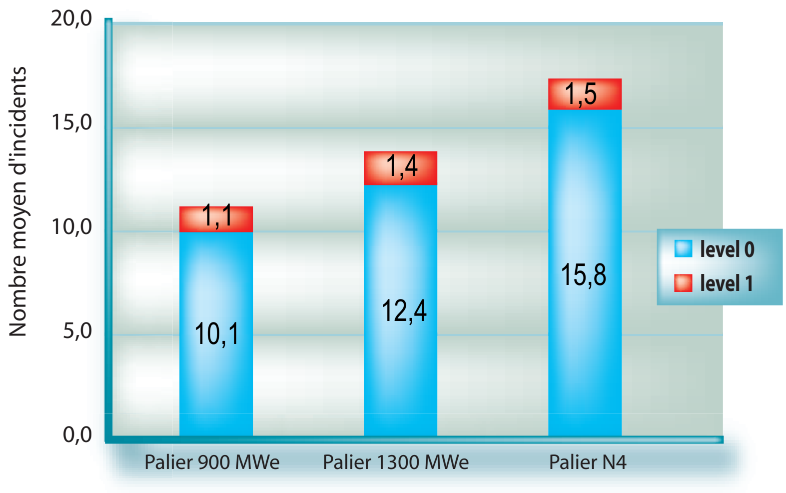
After a slight rise in 2003 and 2004, the number of significant environment events remains low while the number of significant radiation protection events has fallen in relation to 2005. The graph shows a regular rise in the number of significant safety events, but their proportion in relation to the total number of events declared has changed little since 2002.

The proportion of incidents rated 1 on the INES scale is about 10%, or 73 incidents concerning safety, one concerning radiation protection and none concerning the environment. As shown in the following graph, the proportion of the number of level 1 events in relation to the total number of events declared for the year has risen, but is below the figures for 2002 and 2003.



Trend in the percentage of events per level since 2002

The average number of events rated 0 and 1 per year and per reactor can be broken down differently according to the plant series, as shown in the following graph.



Average number of incidents per year and per EDF reactor for the year 2006

2 | 2 | 3

Periodic safety reviews

In France, ASN has asked the licensee to carry out a complete "check-up" on each NPP at intervals of 10 years, called the periodic safety review. This is an opportunity for in-depth inspection of the installations to check that they comply with all the safety standards. It is also an opportunity to compare the safety level of the installations with the more recent installations and to make the modifications considered to be necessary with a view to improving safety. In this respect, the safety reviews are one of the cornerstones of ASN policy, which is to ensure that not only does the licensee maintain the level of safety of its installations, but also improves it.

The safety reviews therefore have two primary objectives:

• firstly, to compare the level of safety of the facilities with their initial safety reference framework in order to identify any deterioration over time, as well as the faults and weaknesses of the safety analysis. This is the conformity review;

• secondly, to compare the safety of the facilities with the most recent safety standards, in order to improve the level of safety. This is the safety review. This review aims to identify modifications likely to bring about a significant improvement in the safety level and establish a new "safety reference framework". Advantage is taken of the 10-yearly reactor outages (see point 1|2|3) for deployment of these safety improvements.

The periodic safety review process comprises an orientation phase during which the topics and scope of the conformity and review studies are determined, a study phase aimed at determining the modifications to be made, and a modifications review phase. After the study phase, the choice of topics for the reactor conformity review is finalised. Each of the phases in principle comprises a proposal from the licensee, consultation of the Advisory Committee for nuclear reactors and a position from ASN. Before the first ten-yearly outage associated with the safety review, ASN must rule on the results of the approach, on the acceptability of the new safety reference framework and the continued operation of the reactors following their ten-yearly outage.

The twenty-year safety review for the 900 MWe reactors

Implementation of the modifications arising from this safety review continued during the course of 2006 on the occasion of the second ten-yearly outages at Gravelines 5, Cruas 4 and Chinon B2, and will end in 2010 with Chinon B4. Among the modifications made by EDF could be mentioned those aimed at improving the reliability of the backup turbine generator, the steam generators auxiliary feedwater system and the ventilation systems in premises housing safeguard equipment.

The thirty-year safety review for the 900 MWe reactors

After defining the guidelines for this periodic safety review in 2003, ASN consulted the Advisory committee for nuclear reactors at the end of 2004 and in the first half of 2005 concerning the various study topics, in particular serious accidents, containment of radioactive materials, fire, explosion risks and the use of probabilistic safety studies. Subsequent to these consultations, ASN requested modifications and additional studies for possible design or operation changes. Implementation of the modifications arising from this safety review is scheduled for the third ten-yearly outages on the 900 MWe reactors, from 2009 to 2020.

The twenty-year safety review for the 1300 MWe reactors

Subsequent to the safety review, ASN declared itself to be in favour of continued operation of the 1300 MWe reactors up to their third ten-yearly outage.

Implementation of the modifications arising from this safety review continued during the course of 2006 on the occasion of the second ten-yearly outages at Paluel 1 and Cattenom 1. It will continue on the other 1300 MWe reactors until 2014. Of the modifications implemented by EDF, particularly noteworthy are those designed to improve the fuel handling operations during refuelling outages, or activation of the backup pumps from the control room if the reactor's off-site electricity supply is lost.

2 | 2 | 4

Modifications made to equipment and to operating rules

As part of the process of continuous improvement of the safety of its reactors, but also to improve the industrial performance of its production tool, EDF periodically makes changes to equipment and operating rules. These changes can be the normal result of the correction of conformity deviations, periodic safety reviews, or taking account of experience feedback.

ASN has set up a process to approve these modifications, compatible with the reactor safety issues.

The first part of this process aims to modulate the level of review according to the importance for safety. Equipment changes are divided into three groups. Groups 1 and 2, which have the highest safety impact, are subject to prior ASN approval.

The second part specifies the nature of the information ASN expects from the licensee by stipulating the content and transmission frequency of certain information documents.

In 2006, ASN approvals mainly concerned equipment changes made during the second ten-yearly outages of the 1300 MWe reactors.

Documentary changes are subject to prior approval by ASN when they affect chapters III, VI, VII, IX or X of the general operating rules, presented in section 1|2|2.

2 | 3

Nuclear power plant ageing

Nuclear power plants, like all industrial installations, are subject to ageing. ASN's role on this point is to ensure that EDF general operating strategy takes account of ageing-related phenomena in order to maintain a level of safety compatible with the regulations throughout the life of the installation.

2 | 3 | 1

A relatively young population of nuclear power plants

The nuclear power plants currently in operation were built in a relatively short space of time: 45 reactors, representing 50,000 MWe, or three quarters of the nuclear power plants, were commissioned between 1979 and 1990, with an additional 10,000 MWe between 1990 and 2000.

In December 2006:
- the average age of the thirty-four 900 MWe reactors was 25 years (between 19 and 29);
- the average age of the twenty 1300 MWe reactors was 19 years (between 14 and 22).

Apart from the Chinese nuclear power plants, the French NPP population is the youngest in all the leading nuclear countries.

2 | 3 | 2

The main factors in ageing

To understand the ageing of a nuclear power plant, other than simply the time that has elapsed since it was commissioned, a number of factors must be looked at.

The lifetime of non-replaceable items

In the design, a certain number of reactor components were designed on the basis of a predetermined operating period. These components require close surveillance ensuring that their ageing rate is indeed as expected. This is particular the case with the reactor vessel, designed to withstand embrittlement of the core zone steel as a result of neutron irradiation for a period of 40 years (equivalent to 32 years of continuous operation). The reactor vessel is checked by monitoring "control samples" of metal and appraising them at regular intervals.

Deterioration of replaceable items

This involves phenomena such as wearing of mechanical parts, hardening and crazing of polymers, corrosion of metals, etc. The materials must be given special attention in their design and manufacture (particularly the choice of materials) and must be the subject of surveillance and preventive maintenance and a repair or replacement programme as and when necessary. It must also be possible to demonstrate the feasibility of possible replacement.

Equipment or component obsolescence

The availability of spares which have been qualified for installation in the reactors is highly dependent on any changes occurring within the suppliers' industrial situation.

Should the manufacturer cease to make certain components, or simply go out of business, this could create spares procurement problems for certain systems.

New spares would then require safety justification before they could be installed in the reactors.

Given the length of this procedure, the licensees must adopt a vigorous forward-looking policy in this area.

The ability of the facility to follow changes in safety requirements

Greater knowledge and technological improvements, as well as changes in the social acceptability of risk are also factors which can lead to the decision that an industrial facility requires extensive renovation work or - if this cannot be done at an acceptable cost - to closure at a time in the future to be defined.

2 | 3 | 3

Strategy to deal with equipment ageing

This "defence in depth" type strategy is based on three lines of defence.

Including ageing in the design

The design and manufacture of components, the choice of materials and the installation arrangements must be tailored to the intended operating conditions and take account of the known or presumed deterioration processes.

Monitoring and anticipating ageing phenomena

Deterioration phenomena other than those included in the design may be brought to light during the course of operation. Periodic surveillance and preventive maintenance programmes, conformity reviews (see 2|3|1), or experience feedback reviews are ways of detecting these phenomena.

Repairing, modifying or replacing equipment likely to be affected

This type of action has to be planned in advance, given the procurement lead-times for new components, the maintenance preparation time, the risk of obsolescence of certain components and the risk of gradual loss of staff technical skills.

2 | 3 | 4

ASN policy

From a strictly regulatory standpoint, in France there is no limit on the time that a nuclear power plant is authorised to operate.

However, practice in France is to require that the licensee conduct a periodic safety review of its installation every ten years. The safety review is an opportunity for an in-depth analysis of the effects of ageing. It is also the time when the need for and feasibility of changes to the installation are reviewed, to take account of safety requirements (see point 2|3|2).

In preparation for the 900 MWe reactors third ten-yearly outages, ASN therefore asked EDF to present a precise account of the ageing status of each reactor concerned and demonstrate the possibility of continuing with operation beyond 30 years in satisfactory safety conditions.

In response to this request, EDF drew up a programme of work concerning management of the ageing of its 900 MWe reactors. The results of this work is being reviewed on a number of occasions by the Advisory Committee for nuclear reactors and the Standing Nuclear Section (SPN) of the Central Committee for Pressure Vessels. At the end of this review process, ASN will adopt a stance for each individual reactor regarding continued operation beyond the third ten-yearly outages.

In 2005, EDF sent ASN the initial data resulting from implementation of this work programme. In 2006, after obtaining the opinion of the Advisory Committee for reactors, ASN asked EDF for further details, in particular concerning the large-scale R&D resources available.

2 | 4

The EPR project

2 | 4 | 1

EPR safety options

ASN considers that the safety of the reactors at present in operation in France is satisfactory. However, it considers that the new generation of PWR reactors must be even safer.

Therefore, in 1993, the French and German nuclear safety authorities together set stricter safety objectives for the EPR (European Pressurized water Reactor) project, as part of an evolutionary design process taking advantage of the experience gained from the reactors in operation:
- the number of incidents must be brought down, in particular by improving systems reliability and taking greater account of human factors;
- the risk of core meltdown must be reduced even further;
- the potential radioactive releases from all conceivable accidents must be minimised.

Finally, owing to the operational experience acquired with the reactors in service, ASN also asked that the operational constraints and human factors aspects be taken into account as of the design stage, in particular with a view to improving worker radiation protection, limiting radioactive releases and minimising the quantity and activity of the waste produced.

The objectives set led the reactor designers to propose a certain number of improvements to the safety options, including the following examples:
- concerning the reduced risk of accident, greater diversification and redundancy of equipment performing safety functions or a significant reinforcement in civil engineering of the nuclear island to

offer greater protection against external hazards, including earthquakes, industrial explosions and aircraft crashes;
– concerning designed-in management of serious accidents, the positioning under the reactor vessel of a device specially designed to recover, contain and cool a molten core.

2 | 4 | 2

Flamanville 3 "first off" EPR - authorisation decree

On 9 May 2006, EDF sent the Ministers responsible for Industry and the Environment an application for authorisation to create an EPR reactor on the Flamanville site.

Public debate

On 4 November 2004, EDF had already contacted the National Public Debates Commission (CNDP) concerning the construction project, in accordance with the Environment Code. The Commission decided to hold a public debate, with a special committee given responsibility for organising it.

Nineteen public meetings, at which ASN took part, were held both in the region in which the project was to be located and nationwide, from 19 October 2005 to 18 February 2006.

At the same time, two working groups were set up by the special committee: a first group looked at anticipated electricity requirements while a second group looked at access to information and secret data. ASN took part in the second group. The debate made it easier for the public to obtain information about the issues and objectives of the project. In its conclusions, the special committee considered that new methods of promoting the expression of expertise from a variety of backgrounds were required in order to develop the public civil nuclear debate.

Following the debate, on 14 September 2006, EDF released a public version of the project's preliminary safety case and placed it on its website. In a letter sent to ASN, EDF also made a commitment to promote public information and the expression of opinions by experts with recognised competence on the Flamanville 3 reactor project, to analyse the observations designed to improve its operation, its safety and its impacts, and to take account of them insofar as is possible.

Review of the authorisation decree application

It was at the conclusion of the public debate that EDF submitted the above-mentioned application for the authorisation decree. Once the application was considered acceptable by ASN, the review process ran according to the requirements of the Environment Code and decree 63-118 of 11 December 1963 concerning nuclear installations.

The *préfet*[1] of the Manche *département*[2] held a local public inquiry from 15 June to 31 July 2006. On 12 October 2006, the préfet of the Manche *département* approved the project, based on the conclusions of the report from the commission of inquiry and the opinions expressed during the consultation of the administrative services of the Manche *département* and the municipal councils of the *communes*[3] located within a 10 km radius around the Flamanville nuclear site.

In September 2006, ASN completed its review of the preliminary safety case, which had started in 2002 at the same time as it was being drafted. ASN thus ensured that the data presented to support the application in the reactor preliminary safety case were in conformity with the regulations and with the objectives and technical safety directives defined in 2004 for the EPR.

At the beginning of 2007, ASN will be sending the Government its opinion concerning the reactor authorisation decree.

1. *préfet*: regional government representative
2. *département*: administrative region

If the authorisation decree is issued by the Government, EDF may then begin building the EPR on the Flamanville site. ASN will for its part begin a review of the detailed construction studies and initiate a programme of construction reviews.

2 | 4 | 3

Cooperation with foreign nuclear safety authorities

Continued cooperation between France and Finland

The Finnish electricity utility TVO submitted an application for an EPR reactor building permit in January 2004. After a one-year review of the project, the Finnish nuclear safety authority (STUK) sent the Finnish government a favourable opinion and construction was authorised at the beginning of 2005.

The Finnish and French nuclear safety authorities then reinforced their collaboration on the subject and in addition to sending STUK all the assessment reports already produced in France on the EPR, joint technical meetings are periodically organised to look at the progress of the review procedures implemented by each party. In 2006, two meetings of this type were held.

ASN had exchanges with STUK concerning the qualification process for non-destructive testing, pursuant to the 10 November 1999 order on surveillance of the operation of PWR main primary and secondary systems. Publication of the order of 12 December 2005 concerning nuclear pressure vessels was an opportunity to compare inspection and assessment practices for the design and construction of these components, with regard to the respective regulatory reference documentation. Exchanges also covered technical problems encountered in the manufacture of the main primary system components for the Finnish EPR.

New contacts

After China and Canada in 2005, ASN was contacted by India and South Africa for a presentation in early 2007 of the safety requirements for the EPR generation of reactors, how the technical review of the project was conducted and the authorisation procedure followed.

The bases for multinational cooperation

During the course of 2005, the MDEP (Multinational Design Evaluation Program), initiated by the American nuclear safety authority (NRC), was discussed at an international level. This process aims to establish a framework of exchanges and multinational cooperation for assessment of the design of new nuclear reactors, harmonisation of safety requirements and standardisation of assessment tools.

In October 2005, the first phase of this process was carried out to assess the design of the EPR. In this respect, a request for cooperation was sent by the NRC to the French and Finnish nuclear safety authorities. A cooperation MoU was signed between NRC and ASN to officially ratify this cooperation.

For its part ASN offered NRC cooperation based on the same model as that established with STUK. Within this framework, all the technical assessment reports presented to the Advisory Committee for reactors was made available to NRC, which in July 2006 also attended a session of the Advisory Committee of experts devoted to review of the EPR project.

2 | 5

Research into pressurised water reactor nuclear safety and radiation protection

Fundamental and applied research is one of the keys to progress in the field of nuclear safety and radiation protection, for several reasons:

3. *commune:* smallest administrative subdivision administered by a mayor and a municipal council

- development and validation of innovative technical solutions allow the emergence of new products or operating and maintenance processes and their use in place of techniques or processes offering a lesser degree of protection;
- certain research work aims to improve knowledge of the risks, which will help define the protective measures needed or even shed light on risks hitherto poorly evaluated: this is for example the case with experiments on PWR sump clogging phenomena, or studies into human reliability helping to better quantify the role of human factors;
- finally, research is useful in developing high level skills in the field of nuclear safety and radiation protection, thus helping to ensure that there is a ready supply of specialists.

The fact of being familiar with the latest research results and knowing which questions are still to be answered, means that the nuclear safety authorities know how far a licensee can be pressed to implement safety or radiation protection improvements. ASN therefore remains abreast of research work in order to make its regulatory actions more pertinent. Moreover, the ability of the nuclear safety authorities - or the experts on which they rely - to initiate research also sometimes enables them to identify safety questions that were wrongly considered to have been resolved. For example, interpretation of the experiments conducted by IRSN brought the risk of nuclear reactor sump clogging back into the spotlight.

It is also important for the licensees to make a significant contribution to the nuclear safety and radiation protection research effort, using the results to make their facilities even safer. ASN thus asked EDF to send it an annual statement of the budget and workforce assigned to nuclear safety and radiation protection research, so that it could examine the corresponding trends. ASN's findings today show that EDF's budget in this field has remained at a high level, even if there has been a slight downward trend in recent years. It also observes with satisfaction that research in this area is still driven by a number of factors:
- future reactor projects: the EPR project has led to R&D work into new technical solutions, some of which could be implemented on existing reactors;
- the desire of industry to improve the performance of its tools: for example, EDF's intention to increase nuclear fuel performance in particular generated work on uranium oxide ceramics, cladding materials and the design codes. This work is also a means of increasing the available knowledge and in some cases advancing the safety level, for example by highlighting weaknesses in the methods previously used;
- the reactor lifetime issue. EDF's wish to continue with operation of the existing plants initiated research into materials ageing and the evolution of structures and components, particularly the performance of the concrete containments and the properties of steel under the effects of irradiation;
- taking account of experience feedback from incidents; for example the research into the risk of flooding or modelling of oil slick drift.

3 PLANT SAFETY

3 | 1

Regulation of construction

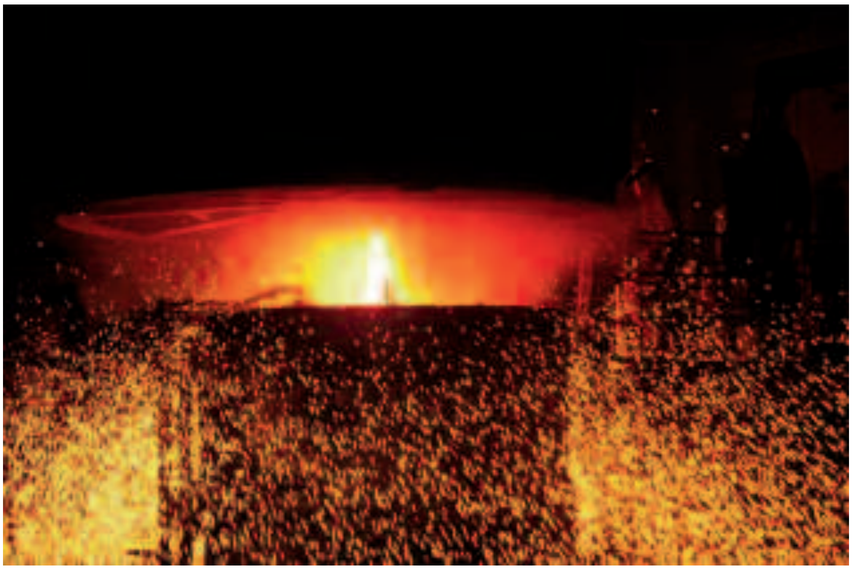
Achieving the general safety and radiation protection objectives requires that the nuclear installations are designed, built and operated in compliance with the technical, organisational and regulatory requirements assigned to them. In this respect, ASN carries out regulatory and inspection duties at all stages in the life of a nuclear power plant.

As part of its technical review of the EPR project, ASN in 2006 began to look at a regulatory and regulatory programme for the construction of a new reactor. The purpose of this work is to prepare ASN, possibly as of 2007, to regulate EPR construction work, incorporating the experience feedback from the construction of existing French reactors and the construction of the Finnish EPR currently underway.

Concerning pressure vessels containing radioactive fluids, ASN keeps a close watch on manufacturing operations, particularly for PWR main primary and secondary systems. The design, factory manufacture and on-site assembly of the equipment is the responsibility of the manufacturer as defined in the European directive on pressure vessels. It is up to the manufacturer to demonstrate the conformity of the equipment it designs in its justification files. It chooses the manufacturing processes, the checks to be used and the acceptance criteria for the results of these checks. It is also up to the manufacturer to supervise its suppliers and subcontractors.

For the entire process, ASN conducts checks, or has checks run by organisations approved by itself, into manufacturer compliance with the essential safety requirements and radiation protection requirements imposed by the regulations.

This construction supervision takes place:
• during design, on the basis of the justification files provided by the subcontractor. These files describe the equipment and its components, the loads to which they are subjected in normal operation or would be subjected to in an accident situation as presented in the safety case, their mechanical behaviour in response to these loads, the characteristics of the materials used, the manufacturing and supervision processes;



Casting of steel intended for a steam generator tube sheet at the JSW foundry, Muroran, Japan

• during manufacture/installation: on the one hand prior to the beginning of these operations, based on documents describing the technical options adopted by the subcontractor, and on the other hand during execution, via checks in the field and in the factory, to ensure compliance with the regulations concerning equipment dimensions, materials used, manufacturing processes employed and their qualification, the supervision carried out and its results.

It ends with a review comprising a hydrostatic test. ASN or the accepted organisation is responsible for overseeing the hydrostatic test, which is the final full-scale strength and tightness test, decides on its outcome and issues the test report, without which no pressurised equipment can be brought into service.

3 | 2

Operation and control

3 | 2 | 1

Normal operating conditions

Operating technical specifications (STEs)

The general operating rules (RGEs) contain the reactor's operating technical specifications (STE) (chapter III of the RGEs). Their role is:
- to define the normal operating limits of the facility if it is to remain in conformity with the reactor design basis scenarios;
- depending on the state of the reactor, to define the safety functions necessary for the monitoring, protection and safeguard of barriers as well as implementation of incident and accident operating procedures;
- to specify the course of action to be followed if a normal operating limit is exceeded or if a required safety function is unavailable.

Permanent modifications to the STEs

EDF may be led to modify the STEs for various reasons: to take account of experience feedback, to improve safety, to improve reactor economic performance, or to take account of the consequences of changes made to the equipment. These changes in the STEs require prior authorisation by ASN on the basis of safety justifications provided by EDF.

In 2006, ASN reviewed a number of documents modifying the STEs, which were approved or are the subject of additional justification requests. These include:
- a new version of the N4 series STE linked to the "end of series state" technical and documentary level;
- a document amending the STE for the CP0 plant series, enabling greater account to be taken of the primary system moderate leak accidents.

ASN also continued with review of several other dossiers, including a new version of the STE for the CPY plant series and a document amending the STE for the CPY series linked to implementation of the new "MOX parity" fuel management.

ASN considers that EDF's document support policy, in particular through highlighting the proposed changes, facilitates analysis and review.

Temporary STE modifications

When a licensee considers that it is unable or does not wish, on safety grounds, to comply strictly with STEs during an operating or maintenance phase, it must apply to ASN for a waiver. ASN then analyses this request and may accept it, if necessary provided that compensatory measures are taken.

ASN remains vigilant regarding the number of waivers and carries out a detailed analysis every year, on the basis of data produced by EDF. EDF is therefore required:
- periodically to re-examine the reasons for the waiver requests in order to identify those which would justify adaptation of the STEs;
- to identify "generic" waivers, in particular those linked to implementation of national modifications and periodic tests.

The number of waivers reviewed in 2006 was 120, or an average of about 2.1 per reactor, per year. The three most commonly evoked reasons for waiver requests in 2006 are linked to:
- maintenance on the nuclear auxiliaries building ventilation system.
- start-up of a reactor building ventilation system following heat insulation replacement operations;
- maintenance work on the power plant electricity supply auxiliary transformers.

Although most waiver requests are granted, ASN's waiver approvals sometimes stipulate additional requirements owing to the inadequacy of the palliative measures proposed by the licensee.

Field review of normal operation

During nuclear power plant reviews, ASN checks:
- compliance with the STEs and, as necessary, with the palliative measures associated with the waivers;
- the normal operating document quality such as operating instructions or certain alarm sheets;
- consistency between the normal operating documents and the STE;
- staff training in handling certain "sensitive" reactor transients, such as residual heat removal system (RRA) mid-loop operation (PTB).

3 | 2 | 2

Incidents or accident operations

In the event of a reactor incident or accident, the operation teams have specific operating documents at their disposal, designed to enable them to keep the reactor in or return it to a stable condition.

Incident and accident operation today uses the state-based approach (APE). The APE consists in implementing operating strategies which are designed according to the identified physical state of the nuclear steam supply system, regardless of the events that led to this state. Should the state deteriorate, a permanent diagnosis enables the procedure or sequence in progress to be aborted and a more appropriate procedure or sequence to be applied.

The operating documents used in incident and accident situations are developed on the basis of incident and accident operating rules which constitute chapter VI of the general operating rules. These rules, which describe operating strategies in the event of an incident or accident, must be approved by ASN.

During 2006, ASN continued to review changes to the operating rules proposed by EDF and in particular approved:
- the amendment file for implementing "MOX-parity" fuel management on the CPY plant series reactors;
- updating of the CPY plant series rules, in particular taking account of experience feedback and the commitments made by EDF with regard to state-based approach (APE) operations.

2006 also saw the beginning of analysis of the "incident or accident operations" (CIA) project. EDF initiated this project following investigation of the frequency of changes to APE procedures as a result of detected incidents which are not managed in optimum conditions by APE operations and in order to ensure that skills are maintained in incident or accident operating conditions.

The main objectives of this project are:
- to manage changes to the APE procedures in order to prevent them becoming over-complex;
- to clarify the interfaces between the incident or accident operating procedures, normal operations and the national emergency organisation;
- to improve the effectiveness of the operations staff in the event of an incident or accident;
- to optimise management of resources and skills in this particular field.

Regular inspections are held on the subject of incident and accident operation. These inspections in particular review the management of incident and accident operation documents (transcription of reference national documents into local documents, reproduction, distribution, etc.), management of specific equipment used in accident operation conditions, and training of operation staff. The inspections performed in 2006 highlighted no major operational issues and ASN on the whole considers that the sites have satisfactorily assimilated incident and accident operation rules (transcription into local documents, distribution and training of staff).

Reactor operation in severe accident situations

If the reactor cannot be brought to a stable condition after an incident or accident and the scenario resulting from a series of failures leads to core damage (core melt), the reactor is said to be entering a severe accident situation.

For this type of very hypothetical situation various steps are taken to enable the operators, supported by the emergency teams, to manage reactor operation and ensure containment of radioactive materials in order to minimise the consequences of the accident. The emergency teams may in particular use the serious accident response guide (GIAG). In 2006, EDF completed transcription of the GIAG into operator documents for all plant series. These documents are intended for use by the operating teams, plant duty teams and local and national emergency teams.

The GIAG and its upgrades are currently being reviewed by ASN and its technical support organisation.

In October 2006, IRSN, CEA and EDF presented the Advisory Committee for reactors with a joint summary of the current state of severe accidents research in France and abroad. If the core deterioration phase (rod oxidisation and clad bursts) is well-understood and modelled, there are still uncertainties concerning phenomena that occur later and in particular the behaviour of the corium at the bottom of the vessel. Numerous studies and experiments are in progress or planned for the coming years in France and abroad, to gain a clearer understanding of and model the physical phenomena involved in a serious accident.

A meeting of the Advisory Committee for reactors, devoted to severe accidents, is scheduled for 2008. The main subject that will be dealt with concerns the possibility of cooling the corium in the vessel and the associated risks, the risk of corium criticality, the countermeasures to prevent water-borne dissemination of radioactive materials and the new version of the severe accident reference documentation comprising long-term management of accidents.

3 | 3

Maintenance and testing

3 | 3 | 1

Maintenance practices

Deregulation of the electricity market leads EDF to control its expenditure. Optimising maintenance costs is one way for EDF to improve its competitiveness. EDF has therefore developed a “maintenance reduction” project which aims to concentrate maintenance on equipment which would constitute a safety, radiation protection or operational risk in the event of failure, and is relying on maintenance methods which do not require equipment disassembly.

A first change occurred in the mid-90s with implementation of the "reliability centred maintenance" (RCM) method. This consists of a functional analysis which determines the type of maintenance to be carried out according to the consequences of equipment failure on the system concerned, rather than simply according to its causes, as in the previous approach. ASN considered that this approach did not compromise safety.

Further to requests from ASN and to take account of experience feedback from the plants, EDF revised the RCM method to deal with redundancy loss and common mode failures, as well as failure modes that could not be detected from the control room.

Taking advantage of reactor standardisation in France, EDF is also developing the concept of "pilot equipment" based maintenance, creating technically homogeneous families of similar equipment operated in the same way. The selection and close monitoring of a limited number of these items - which then act as pilot items within these families - could, if no deterioration is detected, spare systematic monitoring of all the items.

ASN is closely monitoring how EDF takes account of experience feedback about the behaviour of the equipment concerned by these maintenance methodology changes, in particular with regard to the content and frequency of the inspections.

3 | 3 | 2

Qualification of scientific applications

The scientific applications contributing to the safety demonstrations are subject to the requirements of the order of 10 August 1984 concerning the quality of the design, construction and operation of BNIs (see chapter 3, point 2|2|1). One of the key requirements is qualification, which consists in ensuring that the application can be used in complete confidence within a specific field.

On the occasion of the inspections into this subject, ASN observed shortcomings concerning the inventory of scientific applications used in the safety demonstrations, the production of qualification files and the supervision of these files, particularly in the case of subcontracted studies.

In 2005, ASN asked EDF to take the necessary corrective action. In response, EDF proposed an organisation common to the various entities for implementation of the scientific applications used in the studies supporting the safety demonstration. ASN began a review of implementation of this type of management at the EDF Construction and Operation Appraisal and Inspection Centre (CEIDRE). ASN observed that this had only been partially achieved within the CEIDRE, contrary to the undertaking made in conformity with these principles in June 2006. ASN will continue this review into 2007.

ASN in 2006 also analysed the qualification file for the Science neutron computing system. When it transmitted its conclusions to EDF, ASN mentioned that it intended to produce a more general definition of the principles and procedures to be used for the qualification review of the computer codes used in the safety demonstrations.

3 | 3 | 3

Qualification of inspection methods

Work done internationally has highlighted the need for a strict demonstration that the inspection methods used for operational surveillance of reactor main primary and secondary systems are indeed able to detect potential damage.

It must be proven that the inspections used for operational surveillance of reactor main primary and secondary systems are indeed able to detect potential damage.

Ultrasound inspection of a welded joint

Article 8 of the order of 10 November 1999 therefore specifies that the "non-destructive examination processes used on operational equipment must be qualified prior to use by an entity chosen by the licensee", whose competence and independence must be demonstrated.

The order states that this qualification will be granted by a qualification board recognised as competent and independent of both those directly operating the reactors and those directly involved in developing the processes.

This board, chosen by EDF, received accreditation from COFRAC (French Accreditation Committee). It assesses the representativeness of the mock-ups used for the demonstration and the faults introduced into them. On the basis of the qualification results, it confirms that the performance of the examination method is as expected. A description of the qualification process has also been codified in the RSE-M code. As applicable, this entails either demonstrating that the inspection technique used is able to detect a deterioration described in the specifications, or describing in detail the performance obtained with the method.

At an international level, the qualification requirements differ appreciably from one country to another, with regard to both the procedures and the levels of the testing methods concerned. The licensees are granted transitional periods of varying lengths for implementation of their respective programmes.

The French aim was to qualify all the non-destructive testing processes used for the operational inspection programmes. The 144 applications were grouped into 76 qualification dossiers, based on technical similarities. At the end of 2006, only a single dossier was still in the final qualification phase. Pending this qualification, special compensatory measures are taken.

3 | 3 | 4

Periodic tests

In order to check the availability of safety-related equipment, in particular the safeguard systems to be used in the event of an accident, good operation tests are periodically carried out.

In 2006, ASN continued to review changes to the periodic test programmes. This chiefly involved:
- review of changes to the periodic test programmes for the reactors of the CP0 plant series with "PTD lot VD2" status;
- approval of the periodic test programmes for the CPY plant series with "PTD lot 93-2000" status;
- approval of changes to the periodic test programmes associated with the second ten-yearly outages for the 1300 MWe reactors;
- approval of changes to the periodic test programmes for the 1,450 MWe reactors with "PTD end of series" status.

ASN accepted the licensee's strategy for revising certain periodic test procedures in order to take greater account of measurement uncertainties during the periodic tests.

ASN also continued to look at how to change procedures for approval of the periodic test programmes.

3 | 4

Fuel

3 | 4 | 1

Fuel management trends

In order to enhance the availability and performance of reactors in operation, EDF, together with the nuclear fuel manufacturers, is looking for and developing improvements to fuels and fuel management.

Since 1996, extending cycle lengths has been a major factor in optimising reactor fuel and operations. This extension is combined with increased fuel enrichment, but the quantity of energy released nonetheless remains limited to an average of 52 GWd/t per fuel assembly, which is the maximum authorised value. ASN keeps a close watch to ensure that changes to fuel management methods are accompanied by a reactor safety demonstration based on the scenarios specific to each type of fuel management. When a management change leads EDF to revise an accident study method, prior examination of it is required and it cannot be implemented without the approval of ASN. To take account of experience feedback from fuel management reviews, ASN in 2006 revised its management review procedures, particularly in terms of the technical content of the various phases of this review.

MOX-parity

MOX-parity management concerns the twenty 900 MWe reactors authorised to recycle plutonium. It is characterised by a higher burnup fraction of the MOX fuel assemblies as a result of the higher number of irradiation cycles (4 reactor cycles instead of 3) and a change in their initial plutonium content (average of 8.65% instead of 7.1%). The purpose of this latter change is to compensate for the isotopic degradation of the plutonium resulting from reprocessing of fuels for which the burnup fraction was raised and to ensure that MOX fuel offers equivalent energy to UO2 fuel enriched 3.7% with uranium 235. The purpose of this management is also to help control the quantities of plutonium generated by the French nuclear power plants.

In 2006, ASN finalised the review of this fuel management and considered that it could be used.

GALICE

As of 2008, EDF envisages replacing the existing GEMMES management, operational on the 20 reactors of the 1300 MWe series, with GALICE management. The uranium 235 enrichment of the fuel assemblies would rise from 4% to 4.5%. The maximum fuel burnup fraction would then be 62 GWd/t and refuelling would be hybrid: some assemblies would undergo three cycles and others four. The average cycle length would still be 18 months, but could eventually be modulated between 15 and 21 months, in order to offer a degree of flexibility when planning refuelling outages.

In 2006, ASN continued its technical review of this fuel management.

ALCADE

ALCADE management is planned as of 2007 for the 4 reactors of the N4 series.

In order to extend the operating cycles for these reactors from 12 to 17 months, uranium 235 enrichment of the fuel assemblies would be raised to 4%. The maximum burnup fraction authorised for these assemblies would however remain unchanged at 52 GWd/t.

In 2006, ASN continued its technical review of this fuel management.

3 | 4 | 2

Fuel assembly modifications

EDF is continuing several experimental programmes aimed at improving both fuel safety and performance levels. The avenues for improvement explored are numerous and concern both the composition and shape of the metal parts of the assembly (clad, skeleton assembly, nozzles, etc.) and the fuel pellet matrix.

M5 alloy

Since 2005, ASN has authorised irradiation of AFA3GlrAA refuelling loads (M5 alloy cladding and structure) for a period of two cycles in several reactors (Cattenom 3, Nogent 2, Civaux 1, Civaux 2, Chooz B1 and Chooz B2).

Questions concerning the loss of coolant accident, the pellet-cladding interaction phenomenon and the impact of M5 on the fuel cycle were the subject of a review which brought to light no obstacle to the widespread use of this type of assembly. Experience feedback is currently being acquired and leaktightness defects which appeared on some of these assemblies are currently being characterised.

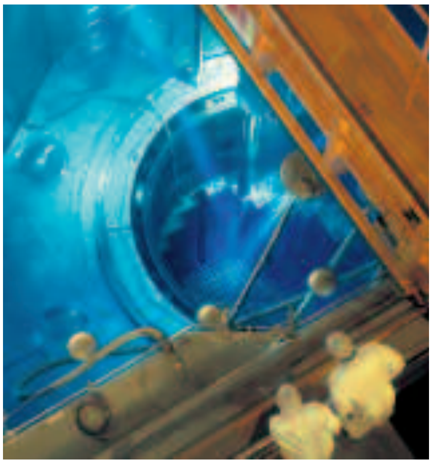
Westinghouse RFA fuel loads

Westinghouse RFA type assemblies are characterised by technologies for holding the rods in their skeleton assembly which are different from those used by Framatome. Since 2005, ASN has authorised the introduction of RFA fuel loads into its 900 MWe reactors and is at present reviewing a request for generalised use of this type of fuel assembly in the 900 MWe reactor series. In the light of the data presented by EDF and satisfactory experience feedback, ASN authorised generalised use of RFA fuel assemblies in its 1300 MWe reactor series.

3 | 4 | 3

Fuel handling operations

Refuelling operations, during which end of life fuel assemblies are replaced by new assemblies, take place with the reactor shutdown and vessel open. Refuelling requires underwater handling of fuel assemblies between the fuel building pond and that in the reactor building, so that they can be positioned in the reactor vessel in accordance with a predetermined plan and pre-defined reloading sequences.



Fuel handling in vessel

In 2006, at the request of ASN, EDF transmitted its analysis of national experience feedback concerning the arrangements put into place to prevent fuel handling accidents such as those which occurred between 2001 and 2004.

These arrangements, particularly the improvements to organisation of the handling staff shift changes and the deployment of cameras able to identify the fuel elements being handled in the fuel building and the reactor building, resulted in effective strengthening of the lines of defence against loading errors and made fuel handling operations more reliable.

3 | 5

The primary and secondary systems

The reactor main primary and secondary systems (CPP and CSP), collectively referred to as the nuclear steam supply system (NSSS) and presented in point 1|1|3, are fundamental components of a reactor. They operate at high temperature and high pressure and as they contribute to all safety functions - confinement, cooling, reactivity control - they are the subject of extensive supervision and maintenance by EDF and in-depth monitoring by ASN. Surveillance of the operation of these systems is regulated by the order of 10 November 1999, mentioned in point 2|2|1 of chapter 3.

On the whole, ASN considered that the condition of the CPP and CSP in the French nuclear power reactors gave no cause for concern in the short term but that the known ageing and deterioration phenomena needed to be taken into account and it asked for appropriate measures in preparation for the third ten-yearly outages of the 900 MWe series.

3 | 5 | 1

System surveillance

When designing the systems, the manufacturer must assess how the NSSS could be damaged by the situations it will experience during operation. Sufficient margin must therefore be designed-in so that the various types of damage identified, particularly fatigue-related phenomena, do not impair NSSS safety.

In order to ensure that the licensee operating a nuclear power plant has assimilated the manufacturer's recommendations and adapted its operating conditions accordingly, the regulations require the creation of "reference files" for the systems.

The licensee must also supervise the systems during operation and set up a documentary system containing the reference files and all events marking the life of the NSSS.

The reference files

The above-mentioned order of 10 November 1999 thus requires that the licensee gather and update all system design, manufacturing and operating data which contribute to justifying system integrity.

Owing to the uniformity of the French reactors, EDF chose to create "plant series" reference files for all the reactors of each series (900 MWe, 1300 MWe and 1450 MWe) with separate "unit" files for each individual reactor. These "unit" files contain data concerning maintenance, faults and events which have occurred on this particular reactor.

Situations counting

During reactor operations, the licensee must therefore check that the NSSS components do not encounter conditions harsher than those provided for in the design. It must in particular count and record in its documentary system those situations actually experienced by the NSSS main systems. The purpose of situations counting is to ensure that the safety margins are maintained throughout the life of the reactor.

Between 2002 and 2006, ASN carried out a series of inspections in order to obtain an overall picture of how EDF performed this activity. ASN observed an improvement over the period 1995-1997 but considered that continued efforts were needed.

With regard to dealing with overshooting of the authorised number of situations, an update of the reference files is planned before the third ten-yearly outages scheduled as of 2009 for the 900 MWe reactor series. This incorporation of experience feedback concerning situation counting is an important factor to be taken into account when demonstrating the ability of these reactors to continue to function beyond thirty years.

3 | 5 | 2

The use of nickel-based alloys

Several parts of a pressurised water reactor are made from nickel-based alloys: tubes, partition plate, primary side coating of the steam generators tubesheet, vessel closure head adapters, vessel bottom head penetrations, vessel internals lower guide support welds, repaired vessel nozzle areas.

The use of this type of alloy is justified by its resistance to generalised or pitting corrosion. However, in reactor operating conditions, one of the alloys adopted, Inconel 600, proved to be susceptible to stress corrosion. This particular corrosion phenomenon occurs when there are high levels of mechanical stress. It can lead to the appearance of cracking, sometimes rapidly as is the case on the steam generator tubes in the early 1980s, or on the 1,300 MWe reactors pressuriser instrumentation taps at the end of the 1980s.

ASN asked the licensee to adopt an overall surveillance and maintenance approach for the zones concerned. Several main primary system zones made of 600 alloy are thus subject to special surveillance. For each one, the in-service surveillance programme, defined and updated annually by the licensee, has to meet requirements concerning the inspection objectives and frequencies. In addition, steam generators and vessel closure heads are covered by a major replacement programme (see point 3|5|4).

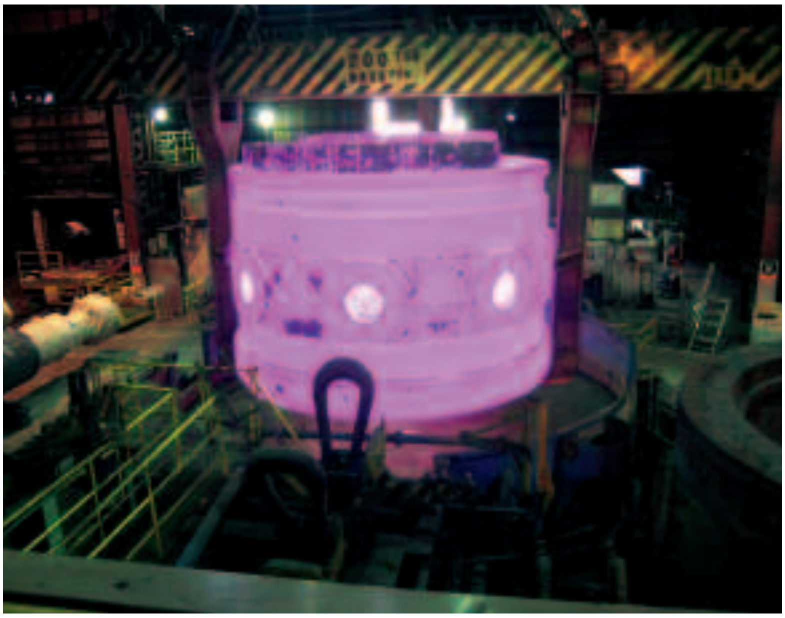
Following the discovery in 2004 of cracks attributable to stress corrosion on the partition plate of a steam generator which had been considered by EDF to be immune in principle to this type of damage, ASN asked EDF to adapt its maintenance strategy to take account of this unexpected damage. EDF developed automatic tools for easier inspection and repair of these zones. This in particular concerns the automatic dye penetrant process which had been qualified in 2006 and the method for ultrasonic characterisation of crack depth employed for assessment purposes on several steam generators. EDF also increased the number of steam generators to be reviewed and in 2006, this led to other stress corrosion cracking indications being observed on partition plates. For the first time, some of these indications had reached a depth far greater than the characterisation threshold.

3 | 5 | 3

Reactor vessels

The vessel is one of the essential components of a PWR. This component is 14 m. high, 4 m. in diameter and 20 cm. thick. It houses the reactor core and its instrumentation and in normal operation is completely filled with water, bringing its weight to 300 t. It can withstand a pressure of 155 bar at a temperature of 300 °C.

Regular and precise monitoring of the state of the reactor vessel is essential for the following two reasons:
- vessel replacement is not envisaged, for reasons of technical feasibility and economics;
- rupture of the vessel is an excluded accident, so its consequences are not included in the reactor safety evaluation. Validating this assumption however means that appropriate design, manufacturing and operating measures be taken.



EPR reactor vessel nozzle support ring undergoing heat treatment

In normal operation, the vessel deteriorates slowly, under the effect of the neutrons resulting from the core fission reaction, which embrittles the metal. This embrittlement makes the vessel particularly sensitive to pressurised thermal shocks or to sudden pressure surges when cold. The presence of a crack would then be potentially damaging.

To prevent all risks of this type, the following measures were taken as of commissioning of the first EDF reactors:
- a program to monitor the effects of irradiation: capsules containing test specimens made of the same metal as the reactor vessel were placed inside the reactor, near the core. Some of these capsules are regularly removed for mechanical testing. The results give a good picture of the ageing of the vessel metal and can even be used to anticipate it, inasmuch as the capsules located near the core receive more neutrons than the metal of the reactor vessel;
- periodic ultrasonic inspection: this inspection is in particular used to check that there is no growth or spread of any manufacturing defects located under the vessel's stainless steel liner.

ASN reviewed the vessel files forwarded by EDF on the occasion of the second ten-yearly outages. It considers that a 30-year lifespan for the 900 MWe reactor vessels has been demonstrated.

ASN however considers that EDF must still demonstrate the life of its vessels beyond 30 years. To do this, EDF provided answers to the questions asked following the session of the SPN of the Central Committee for Pressure Vessels, held in 1999. These answers are given in a summary file which is currently being reviewed and which was reviewed by the SPN experts in 2005.

Following this review and in the light of the results of the checks carried out during the reactors' third ten-yearly outage, ASN will take a stand regarding the vessel operating conditions beyond 30 years.

3 | 5 | 4

Steam generators

The steam generators are exchangers of heat between the water of the primary system and that of the secondary system. The exchange surface consists of a tube bundle comprising about 3,000 to

6,000 tubes, depending on the model. These tubes contain the primary system water and exchange heat while preventing any contact between the primary and secondary fluids.

The integrity of the steam generator tube bundle is a major factor in safety, as any deterioration of the tube bundle could lead to a leak from the primary system to the secondary. Furthermore, a break in one of the bundle tubes in an accident scenario would thus bypass the reactor containment, which is the third confinement barrier. These steam generator tubes are subject to a variety of deterioration phenomena: wear, corrosion, and so on.

The steam generators are covered by a specific in-service surveillance programme drawn up by EDF and revised every 3 years. The current version of this programme was reviewed and accepted by ASN in 2003. Following the checks, those tubes which show excessive levels of damage are plugged to remove them from service.

Since the early 1990s, EDF has been conducting a replacement programme for steam generators with the most heavily damaged tube bundles. This programme will continue at the rate of one reactor a year. At the end of 2006, twelve of the thirty-four 900 MWe reactors will still be equipped with steam generators using non-heat treated Inconel 600 alloy tube bundles (600 MA), which are the main victims of stress corrosion (see point 3|5|2).

In addition to in-service surveillance, the steam generators undergo hydrostatic testing every ten years, as part of the reactor ten-yearly outage inspection programme (see point 1|2|3): the primary system undergoes an overall strength test at a pressure in excess of its normal operating pressure. On the occasion of the second ten-yearly outages for the 900 MWe reactors, which began in 2002, major leaks were found on some of the steam generators most heavily affected by stress corrosion.

On the advice of the SPN of the Central Committee for Pressure Vessels, ASN asked EDF to take particular measures for inspection and maintenance of these steam generators. EDF proposed an early replacement programme scheduling replacement of the steam generators in the twelve 900 MWe reactors still equipped with Inconel 600 MA tube bundles no later than the third ten-yearly outage. At the same time, EDF continued the study and appraisal programme for the 900 and 1,300 MWe reactors equipped with steam generators with heat treated Inconel 600 alloy (600 TT) tube bundles, which had been started in 2005, to gain a clearer understanding of their performance during the hydrostatic test and determine how to avoid leaks during the tests.

During the night of 11 February 2006, a major leak between the primary and secondary systems reached a flowrate of 500 litres per hour and led to the shutdown of the Cruas 4 reactor. This incident was rated 1 on the INES scale.

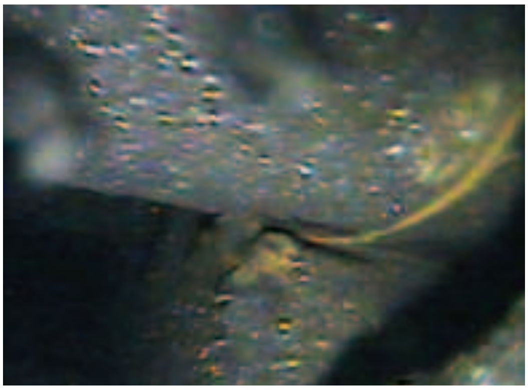
The investigations carried out by EDF determined that the leak came from a fault in the upper spacer plate on steam generator 2. Two similar events, but which led to far smaller leaks, had already taken place at Cruas.

The extremely rapid dynamic of this defect, which appeared and grew in less than three months after more than twenty years of operation, indicates a new deterioration phenomenon based on vibration fatigue, probably linked to the design of the steam generator and a high level of upper spacer plate clogging. Eleven other reactors equipped with steam generators of the same design could be likely to experience the same phenomenon.

EDF implemented a programme of inspections and preventive maintenance. At the same time, the licensee is actively seeking to precisely establish the origin of the phenomenon and is drawing up a strategy for preventing it throughout the reactors concerned.

Finally, to allow diagnosis of a steam generator tube rupture (RTGV) as early as possible, and while waiting for the final data enabling the phenomenon to be fully understood, EDF asked the 18 units equipped with the most vulnerable steam generators to implement an appropriate instruction designed to ensure detection of an evolving primary/secondary leak as early as possible.

Cracked tube internal view



Cracked tube external view

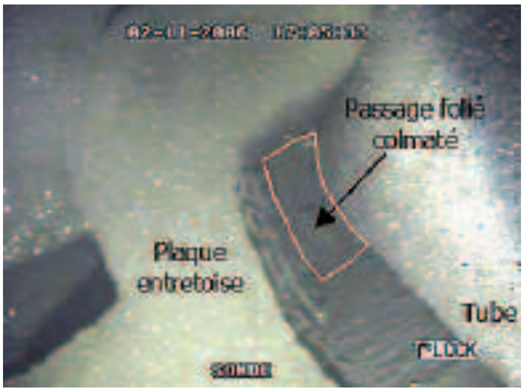


Illustration of clogging

In 2006, failures of various origins on the main secondary systems in units at Blayais 1, Fessenheim 2, Tricastin 4 and Nogent 2, had led to rapid closure of the steam isolating valve. The consequence of these events was to increase the pressure in the main secondary systems, which was limited by opening of the system protection relief valves.

Given that these valves were calibrated to a pressure higher than the steam generator design pressure, these devices underwent requalification to examine the impact of these loadings on the various zones of the device. An analysis of the causes of these various failures will be made in 2007.

3 | 6

Containment

The containments undergo inspections and tests to check their conformity with the safety requirements. Their mechanical performance in particular must guarantee a good degree of reactor building tightness, in the event of its internal pressure exceeding atmospheric pressure, which can happen in some types of accident. This is why these tests, at the end of construction and then during the ten-yearly outages, include a pressure rise up to the inner containment design pressure.

The containments of the 900 MWe reactors consist of a wall of pre-stressed concrete with an interior metal liner. During the ten-yearly tests run on these containments so far, their leak rates have been in conformity with the regulation criteria. Their ageing was reviewed in 2005 as part of the 30-year periodic safety review, to assess their leaktightness and mechanical strength for a further 10 years. This review brought to light no particular problem liable to compromise the length of the service life.

The containments of the 1,300 MWe and 1,450 MWe reactors comprise two concrete walls. A change in the leak rates from the inner wall of some of these containments, mainly under the combined effects of concrete creep and the loss of pre-stressing of certain cables, has been observed in recent years. Although account was taken of these phenomena at the design stage, they were sometimes

Flamanville (Manche) nuclear power plant

underestimated. In an accident situation therefore, certain areas of the wall could find themselves under traction, a stress condition favourable to cracking and therefore leaks. To combat this phenomenon, EDF has implemented a preventive repair programme aimed at restoring the tightness of the most heavily affected areas. On the basis of a recommendation issued by the Advisory Committee for nuclear reactors in 2002, ASN gave EDF its approval of this strategy. This work is done at each ten-yearly outage and by the end of 2006, 19 of the 24 units had been dealt with. All the reactors concerned will have undergone the necessary maintenance work by 2011.

3 | 7

Protection against external hazards

3 | 7 | 1

Earthquakes

The buildings and equipment in NPPs which are important for safety are designed to withstand earthquakes of an intensity higher than all the earthquakes that have already occurred in the vicinity of the site, plus an additional safety margin. The rules for dealing with the seismic risk are regularly updated in order to take account of new data with retroactive application on a case by case basis during the periodic safety reviews. The conformity reviews are also an opportunity for detailed checks. Although when compared with other countries France is not particularly seismic, considerable efforts are devoted to this subject by EDF and close attention is given by ASN.

Updating of the design rules

Several years ago, ASN began work on updating the official texts dealing with the seismic risks in BNIs. In 2001, the new basic safety rule 2001-01 determining the seismic risk for surface BNIs replaced a rule dating back to 1981. This work continued with revision of basic safety rule V.2.g concerning seismic design of civil engineering works. The revised text was published in 2006, in the form of a guide for incorporating the seismic risk in the design of civil engineering works in BNIs, with the exception of radioactive waste long-term disposal facilities. It is the result of several years of work by French experts in the anti-seismic engineering field.

For surface BNIs and based on site data, this text defines the anti-seismic design requirements for civil engineering works and the acceptable methods for:

– determining the seismic response of these works, by considering their interaction with the equipment they contain and assessing the loads associated with the seismic response to be used in the design;
– determining the seismic movements to be considered for the design of the equipment.

Seismic design reviews

Within the framework of the current periodic safety reviews, the seismic design review in particular consists in updating the level of the earthquake to be taken into account, under application of the above-mentioned RFS 2001-01.

For the 30-year periodic safety review on the 900 MWe reactors, ASN asked EDF to review in particular the seismic design of the electrical buildings of the CPY series of reactors (Gravelines, Saint-Laurent-des-Eaux, Dampierre, Cruas, Tricastin, Chinon). For the reactors of the CP0 series, ASN asked EDF to study the seismic design of the nuclear island buildings and the turbine hall. The studies are in progress to define any equipment or structural modifications needed.

With regard to the 20 year safety review for the reactors of the 1300 MWe series, EDF reviewed the seismic stability of the turbine halls in the P'4 type reactors (Cattenom, Nogent-sur-Seine, Belleville, Golfech, Penly) and the strength of the civil engineering structures in the electrical and the safeguard auxiliaries buildings in the P4 type reactor (Flamanville, Paluel, Saint-Alban). These studies revealed that the original design would guarantee that these reactors could withstand the design basis earthquake reassessed in accordance with RFS 2001-01.

3 | 7 | 2

Flooding

Following the flooding of the Blayais site during the December 1999 storm, EDF undertook a reassessment of the off-site flooding risk and protection of the sites against this risk. This reassessment in particular concerned a revision of the maximum design flood level (CMS) (maximum water level used in designing the plant protection works and taking account of additional unforeseen

Protective dyke surrounding the Belleville plant (Loire)

events that could lead to flooding, such as particularly heavy rain, a failure of the water storage tanks, or a rise in the groundwater level). The measures to be taken for the reactors in the event of a rise in the water level was also reassessed. A file was produced for each site and protection improvement works have been defined.

The work made necessary by the flood risk reassessment is in progress and EDF has undertaken to complete work concerning the risk of water ingress by the end of 2007. Authorisation to build a peripheral embankment to protect the Belleville plant was in particular issued and construction work has started. A low peripheral wall around the Bugey site has also been completed.

ASN considers that the progress of studies and work is as expected. Nonetheless, for the particular case of the Tricastin power plant, the CMS reassessment studies have not yet been finalised and additional work is expected in 2007, particularly with regard to the risk of dam failure.

In order to finalise the overall approach to the off-site flooding risk for EDF reactors, but also for other nuclear installations, ASN asked the Advisory Committee for reactors and the Advisory Committee for laboratories and plants for their opinions. A joint meeting of the two groups of experts will be held in the Spring of 2007.

At the same time, the working group for revision of RFS I.2.e to deal with the flooding risk, continued its activities in 2006. This group consists of experts, licensee representatives and ASN. The new BNI flooding risk protection guide will cover the choice of unexpected events likely to lead to flooding of the site, and the methods used to characterise such events. It will concern all BNIs.

3 | 7 | 3

Fire and explosion risks

Fire risk

The fire risk in EDF's nuclear power plants is dealt with using the principle of defence in depth, based on:

- prevention, primarily consisting in:
  - ensuring that the type and quantity of combustible materials present in the premises remains within the sectoring design limits (fire doors and walls, fire dampers, etc.);
  - identifying and analysing the fire risks. In particular, a fire permit must be issued and protective measures taken for all work likely to start a fire;

- the design of the installations, which must prevent a fire spreading and minimise the consequences. This is chiefly based on:
  - the principle of splitting the installation up into sectors designed to contain the fire within a given perimeter;
  - protection of redundant equipment which performs a safety function;
  - firefighting, which should enable a fire to be tackled and extinguished within a time compatible with the duration of the fire and the fire-resistant capability of the fire sectors.

Prevention

With regard to prevention, EDF has implemented its new system of "fire permits" in the plants since 2004.

In 2006, ASN considered that EDF needed to further improve the quality of the fire permit updating process, in particular on the basis of the actual intervention conditions, the additions made to the risk analyses and the compensatory measures actually implemented in the field.

Furthermore, in 2006, EDF began to consider installing fire protection appropriate to the substances, materials and equipment stored during reactor outage periods. ASN will assess the adequacy of these measures and the time needed to implement them in the nuclear power plants.

Design

With regard to design, EDF is completing deployment of the fire-fighting action plan (PAI), to ensure the conformity of and improve fire protection for the 900 MWe and 1,300 MWe reactors. In 2006, during reviews carried out and six-monthly meetings with EDF, ASN checked the progress of the work and compliance with the associated deadlines. ASN thus observed delays in completion of the modifications, particularly repair of the openings for the cable chases and electrical cables. ASN asked that by the end of 2006, EDF complete repair of the openings that could interconnect premises containing redundant equipment. For the other openings, EDF scheduled completion of repair work by the end of the first half of 2007 and ASN reminded EDF that their impact on the fire safety demonstration would need to be analysed and the necessary compensatory measures taken.

During the reviews carried out in 2006, ASN also identified problems with management of loss of sectoring, whether scheduled (for example, when implementing the PAI) or inadvertent. ASN asked EDF to set up an organisation able to manage the new sectoring and ensure that this management system in the nuclear power plants is improved.

Finally, for the 900 MWe reactors, ASN asked EDF to review the studies into modifications to the electrical buildings smoke extraction systems, in order to restore the sectoring of the premises through which the ducts of these systems pass and ensure smoke removal in the event of fire, to facilitate staff evacuation and firefighting.

Firefighting

With regard to firefighting, ASN in 2006 observed that the intervention teams were gradually being called out as soon as the alarm is sounded rather than after the fire has actually been confirmed. It did however note that some nuclear power plants do not immediately send out the intervention teams to all the buildings, because the fire detection system is not yet reliable enough.

ASN also considers that in 2006, the firefighting response times have progressed very little and that EDF must continue to make efforts, in particular with performance of the duties of the intervention teams and to improve the interfaces with the off-site emergency services.

In 2006, under the supervision of the Directorate for Civil Defence and Security (DDSC) at the Ministry of the Interior, two meetings were held by the nuclear power plant managers and the Regional Department of Fire and Rescue Services (SDIS) directorates, during which areas for improvement were identified, particularly with respect to the interface between the organisations, risk analysis and definition of intervention scenarios and means or resources to be deployed in the event of a fire.

Finally, at the end of 2006, ASN asked EDF to review the operator fire action sheets, enabling the reactor to be brought to and kept in a safe condition using the state based approach, in particular the feasibility of the actions required locally in the event of a fire.

Explosion risk

On the basis of the conclusions of the 2002 inspections on this subject, the incidents and the anomalies detected in the plants, ASN asked EDF to improve the way in which the risks of explosion of internal origin are taken into account. It in particular asked EDF to look again at the existing systems for protection against the effects of an explosion of internal origin as part of the periodic safety review of the 900 MWe plant series on the occasion of the third ten-yearly outages and to initiate a similar approach for the other plant series.

The new reference documentation dealing with the risk of internal explosion inside nuclear island buildings associated with the use of hydrogen, was transmitted by EDF in 2006. It is currently being assessed by ASN and its technical support organisation, IRSN. EDF will supplement its studies by including gases other than hydrogen and by extending its analyses to buildings other than the reactor buildings.

With regard to the risk of explosion originating outside the buildings, ASN considers that EDF's overall approach is satisfactory. It however considers that this approach should be supplemented by a probabilistic approach and by a study of the safety consequences of the scenarios adopted. These studies were sent to ASN in 2006 and are also currently being assessed.

3 | 7 | 4

Other hazards

Heatwave and drought

Nuclear power plants are the source of thermal discharges into water courses. These discharges may, as applicable, lead to a temperature rise downstream of the plants, ranging from a few tenths of a degree to several degrees. These discharges are regulated by ministerial orders specific to each site.

In 2006, the exceptional weather conditions observed during the first three weeks of July led to the temperature of the water courses rising above historical values.

To be able to guarantee adequate electricity supplies were the heatwave to persist, EDF obtained a joint order from the Ministers for the Environment, Industry and Health on 22 July 2006, temporarily authorising it to carry out thermal discharges which, depending on the river basin, would lead to a temperature rise of between 0.3°C and 3°C in the water downstream of the site as compared with the water upstream. This exceptional authorisation in the end proved unnecessary.

In addition, although plant safety was unaffected by this exceptional weather situation, ASN also in July 2006 asked EDF to anticipate a possible rise in temperatures, in particular by analysing the potential consequences of a further rise in the temperature of the water courses upstream of the plants on the safety of the installations.

For the CPY plant series sites, ASN in 2006 also undertook a review of the "heatwave" reference documentation proposed by EDF, in order to reassess the operation of the installations in conditions harsher than those included in the design.

Silting of the Chinon NPP water intake

On 30 December 2005, the Chinon nuclear power plant informed ASN that its intake channel was partially silted up.

The intake channel is designed to take the water from the Loire river to the nuclear reactors, in order to cool them. This channel is connected to the river by three underground galleries routing the water from a collection point on the bed of the Loire, several tens of metres from the channel itself. A single gallery is open in normal operation. The mass of sand detected was located in the channel and congested the two closed galleries. The flowrate in the gallery in operation was normal.

Dredging operations were decided on in order to safeguard the water intake.

During these operations, if the third gallery had become silted, a direct weir between the Loire and the channel, which is not susceptible to silting, would have been opened to supply the channel with water. To supplement this system, the licensee installed mobile pumps between the Loire river and the channel, enabling the latter to be supplied if silting of the galleries were to be aggravated by the sand movements caused by dredging.

ASN closely regulated these operations and in particular carried out a site inspection on 2 January 2006, to check the steps taken by the licensee, with the support of the civil protection department, in particular the organisation put into place to deal with a possible rise in gallery silting.

Extraction of 30,000 m3 of sand restored a normal site water intake configuration. Studies were also initiated by EDF to look for the causes of this silting, in order to learn lessons that could be of benefit to the other sites.

3 | 8

Other subjects

3 | 8 | 1

Pressure vessels

Owing to the energy that they could release in the event of failure, regardless of the possible risk related to the fluid (liquid, vapour or gas) that would then be released, pressure vessels entail risks that must be controlled.

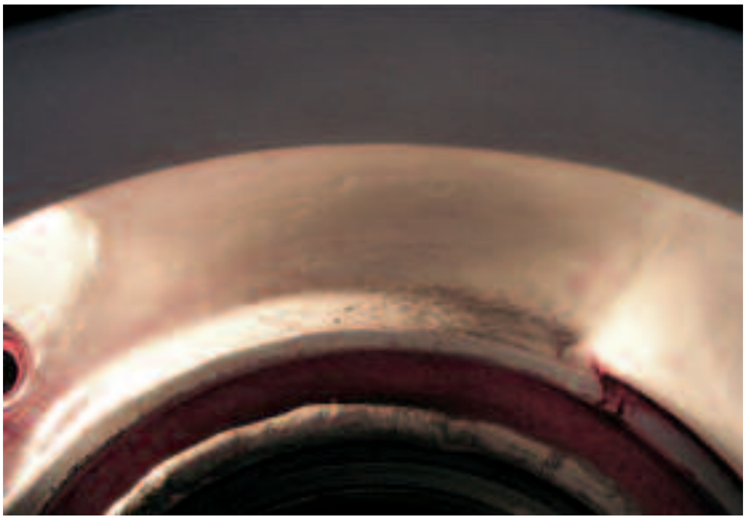
This type of equipment (containers, exchangers, piping, etc.) is also present in many industries such as chemistry, oil treatment, papermaking and refrigeration. It is therefore subject to regulation set by the Minister for Industry, who imposes the requirements with a view to guaranteeing its safe manufacture and operation.

This includes equipment that is liable to emit radioactive releases in the event of failure, as defined in the order of 12 December 2005. In addition to the requirements applicable to conventional pressure vessels and the existing texts covering reactor main primary and secondary systems, this order imposes additional safety requirements on nuclear pressure vessels. The manufacturers and licensees have five years to implement them.

Application of the regulations concerning the operation of pressurised equipment in nuclear reactors is monitored by ASN. In particular through actions on the site, this consists in checking that the licensee, who is responsible for the safety of its equipment, applies the requirements imposed upon it. ASN actions in 2006 include reconnaissance audits and review of the site inspection departments. These departments, under the responsibility of the licensees, are responsible for carrying out equipment safety inspections. Not all the sites as yet have such inspection departments and for the time being only conventional pressure vessels are concerned.

With regard to the events in 2006 concerning pressure vessels important for safety (excluding main primary and secondary systems dealt with in point 3|5), the analyses showed that these events are linked to stress loadings or to a failure to take account of deterioration risks in the design studies and equipment inspection programmes. As a result of these findings, ASN will reinforce its review of the surveillance and inspection programmes on this equipment in 2007.

The significant events include that which occurred in Fessenheim, where thermal fatigue and generalised corrosion damage caused by steam leaks was observed on valves and on the steam generators



Thermal fatigue on the body of valve ASG 135 VV at Fessenheim 2

auxiliary feedwater system (ASG) turbine-driven pump. This event resulted in equipment repair and replacement. ASN asked the licensee to take action, on the one hand to adapt the in-service supervision programme and on the other to eventually put an end to the thermal stress loadings.

Events linked to loadings of both thermohydraulic (mixture of water and steam creating a hammer) and vibratory origin, also took place on other systems important for safety. Events of this type occurred in Gravelines on the Chemical and Volume Control System (RCV) and the Turbine Bypass to Condenser System (GCTc). In the first case, the loads resulted from a leak in the pipe through initiation and propagation of defects. Given the risk of the leak developing and the safety issues, ASN asked that the reactor be shut down as rapidly as possible. In the second case, these loads led to deformation of the supports and to GCTc pipe movements. The pipes were repaired and underwent post-repair qualification by the site inspection department.

3 | 8 | 2

Risks in the workplace

Nuclear power plants are the source of a number of risks to the workers, which are not always linked to the nuclear aspect of the activity. These "conventional" risks are for example linked to the electrical installations, the equipment containing pressurised gas or steam, to the hydrogen systems (explosion risk), to the nitrogen systems (anoxia), to work at height or to handling of heavy loads.

These risks must be dealt with in the first place by the licensee, through application of the regulations in force in any industry, through analysis of the risk inherent in the equipment or the activities, and through implementation of appropriate technical, organisational and human measures.

It should be noted that the steps such as to guarantee personnel safety may in certain cases contribute to nuclear safety: this is for example the case with preventing the risk of explosion, of pressurised equipment bursts or falling loads.

Pursuant to article 57 of Act 2006-686 of 13 June 2006 concerning transparency and security in the nuclear field, ASN staff check that these regulations are applied to nuclear power plants.

4 RADIATION PROTECTION AND ENVIRONMENTAL PROTECTION

4 | 1

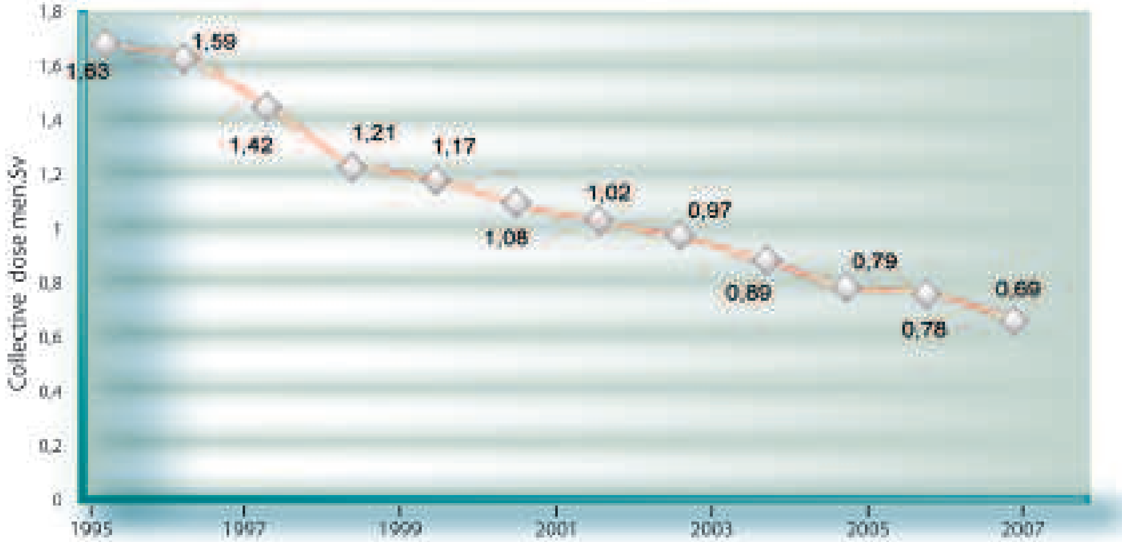
Radiation protection of persons working in nuclear power plants

In a nuclear power plant, ionising radiation comes from a variety of sources, including:
- the fuel;
- equipment activated by the neutron flux;
- the particles resulting from reactor primary system corrosion and conveyed by the primary fluid.

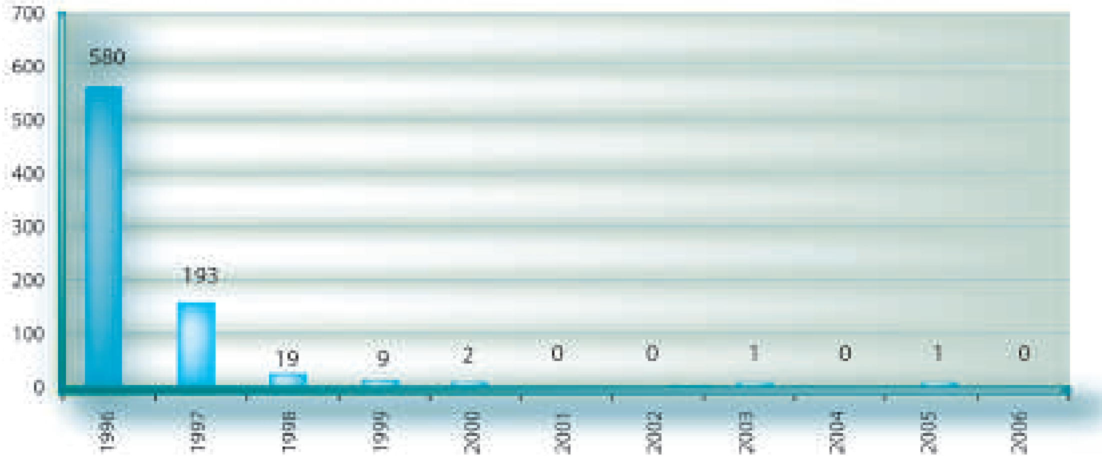
About 80% of worker dosimetry is received during reactor outage maintenance work.

EDF policy

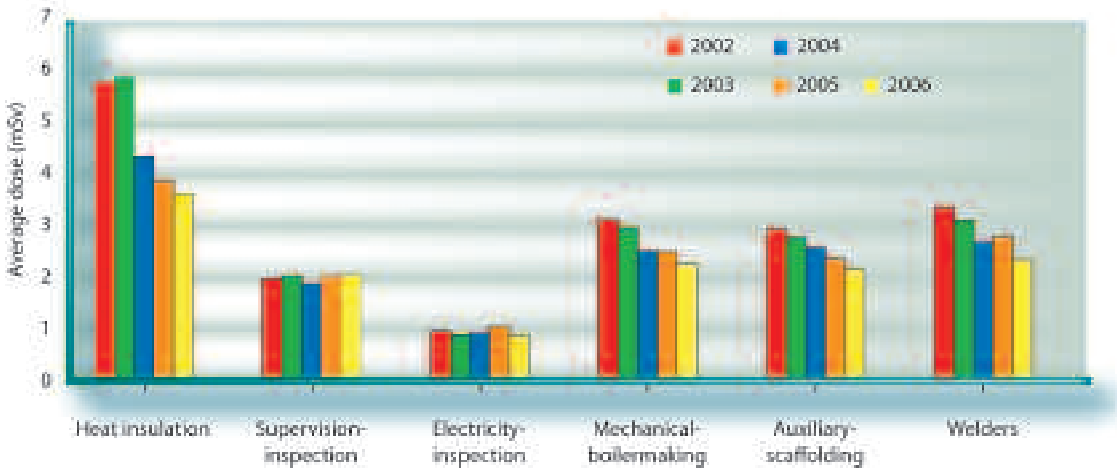
In 1999, EDF undertook to improve radiation protection and establish a level of requirements for it, comparable to that for safety, in particular by:
- defining a new radiation protection organisation;
- setting up forums for exchanges and decision-making;



Mean collective dose per reactor (EDF data)



Number of persons (EDF + contractors) who received a dose higher than 20 mSv (EDF data)



Evolution of average individual dose according to categories of workers involved in reactor maintenance (EDF data)

– creating a radiation protection reference system designed to improve control of regulatory aspects and set up a framework for various subjects linked to radiation protection (radiological cleanness, optimisation, metrology, and so on).

ASN considers that this process is able to remedy the problems encountered by the plants. It has led to a significant reduction in worker dosimetry, in particular collective dosimetry, as illustrated by the following graphs.

The action initiated by ASN

In 2006, ASN continued to check that EDF had correctly taken account of the requests made further to the assessments and inspections carried out between 2002 and 2005 on the pressurised water reactors. ASN paid particularly close attention to radiological cleanness, the chemistry of the primary system, radiography and application of the ALARA approach (IT tools, organisational and material resources for dose counting). The result of these actions and the corresponding assessment are presented in point 5|1 of this chapter.

At the same time, ASN continued with implementation of changes to radiation protection of workers intervening in nuclear power plants, which was defined in 2004. In particular, following on from the analysis conducted in 2005 on a repair operation, ASN in 2006 initiated an analysis into how radiation protection is taken into account in the design and implementation of two modifications to installations defined by the EDF engineering centres.

Finally, ASN benefited from exchanges in 2005 with the Spanish, American and Belgian nuclear safety authorities. ASN highlighted areas of progress for EDF, particularly radiological cleanness, primary system chemistry and real-time dosimetry monitoring on high-risk worksites. ASN was also able to consolidate its regulatory organisation, its inspection practices and its assessment methods.

4 | 2

Discharges from nuclear power plants

4 | 2 | 1

Discharge licence revision

In 2006, ASN continued to review water intake and non-radioactive liquid effluent discharge license applications from nuclear power plants. These licences, issued by the *préfets* under the previous regulatory arrangements, comprise a stipulated validity limit. At the request of ASN, the applications submitted by EDF concern water intake and all discharges, be they liquid or gaseous, radioactive or non-radioactive. These dossiers are subject to a public enquiry. The ASN's goal is for most of the existing licences to be reviewed in the next few years, in order to harmonise the specifications applicable to the various sites.

The renewals currently being reviewed were presented by EDF as soon as the previous licences reached their expiration dates. Thus, at the end of 2006, twelve nuclear power plants were covered by a new effluent discharge and water intake licence. Submissions of applications for the other plants will be staggered until 2009.

These renewals enable ASN to group in a single document all the requirements previously specified by different ministerial or prefectural orders, according to the type of discharge concerned. These requirements in particular specify the quantities, concentrations and surveillance procedures for the pollutants likely to be found in the discharges and in the environment, in accordance with the order of 26 November 1999 laying down the general technical specifications concerning the limits and sampling procedures of the discharges subject to licensing carried out by BNIs. In this context, ASN decided to modify the terms and conditions regulating discharge according to the following principles:

– with regard to radioactive discharges, the real discharges from NPPs are constantly decreasy and are well below current limit values, so ASN is reducing these limit values. For each of the 900 MWe and 1,300 MWe plant series, it has set new limit values based on the experience feedback from real discharges, while taking account of the unexpected events occurring during routine operation of the reactors. The discharge limits have thus been cut by a factor of between 1 and nearly 40, depending on the current fuel management parameters. They have however risen by a factor of 1.25 for liquid tritium discharges, assuming future high burnup fraction fuel management;

– with regard to non-radioactive materials, ASN decided to regulate discharges more exhaustively than in the previous regulations.

4 | 2 | 2

Procedures carried out in 2006

Complete revision of the discharge and water intake licences

In 2006, ASN completed its review of renewal of the water intake and effluent discharge licence for the Golfech nuclear power plant, which has been covered by a new order since 18 September 2006.

The review of the discharge and water intake licence renewal applications for the Dampierre, Tricastin and Penly power plants continued in 2006. An additional application for the Chooz power plant was submitted during the course of the year.

Finally, in August 2006, EDF submitted another application for a water intake and effluent discharge license for the two existing reactors at the Flamanville nuclear power plant, already covered by a ministerial order of 11 May 2000, and the future EPR reactor, which is also the subject of a simultaneous application for its authorisation decree.

Partial revisions

Further to the formal notice delivered in 2003 by ASN for failure to comply with certain discharge limit values in the effluent discharge and water intake licence of 2 February 1999, the licensee operating the Saint-Laurent-des-Eaux nuclear power plant submitted an application in 2004 for modification of its discharge licence. Examination of this application concluded that the modifications requested by the licensee were not significant. The order amending the order of 2 February 1999 was thus signed on 21 February 2006.

A request for modification of the water intake and effluent discharge licence of 8 November 2000 for the Belleville-sur-Loire power plant is currently being reviewed. It mainly concerns revision of the tritium discharge limit values and certain chemical parameters such as those applicable to metals (copper and zinc), changes to the secondary system conditioning method and the use of biocidal and anti-scaling treatment in the condensers cooling circuits.

In August 2006, EDF also submitted a request for modification of the ministerial order of 7 November 2003 regulating water intake and effluent discharge by the Cruas-Meysse nuclear power plant. This file concerns modifications comparable to those mentioned above for the Belleville plant. It also incorporates a number of additional requests concerning the conditions for discharge of radioactive effluent into the Rhône river, the dredging of water supply structures and the use of monochloramine treatment against the spread of legionella bacteria in the secondary systems cooling circuits.

Review of management of associated radioactive and non-radioactive effluent

ASN decided to consult the Advisory Committee for nuclear reactors concerning the management of radioactive effluent and of certain non-radioactive effluent discharged by the French nuclear power plants in operation and concerning the various ways of improving the situation. This review will cover liquid and gaseous radioactive effluent and the associated chemical materials, on the one hand in normal operating situations and on the other in certain external hazard situations.

The technical review conducted by IRSN began in 2006. The opinion of the Advisory Committee of experts is expected by the end of 2007.

4 | 2 | 3

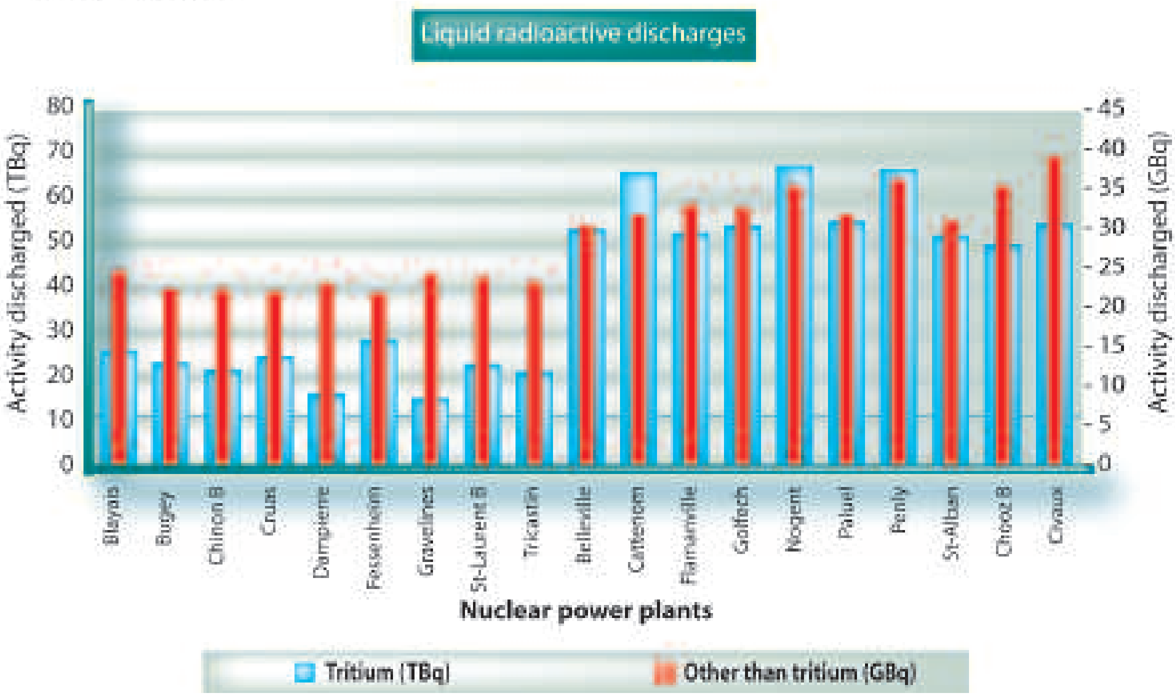
Radioactive discharge values

Discharges in 2006

Every month the licensee communicates its discharge results to ASN. These data are regularly cross-checked against reactor operation during the period considered. Anomalies detected give rise to requests for complementary information from the licensee.

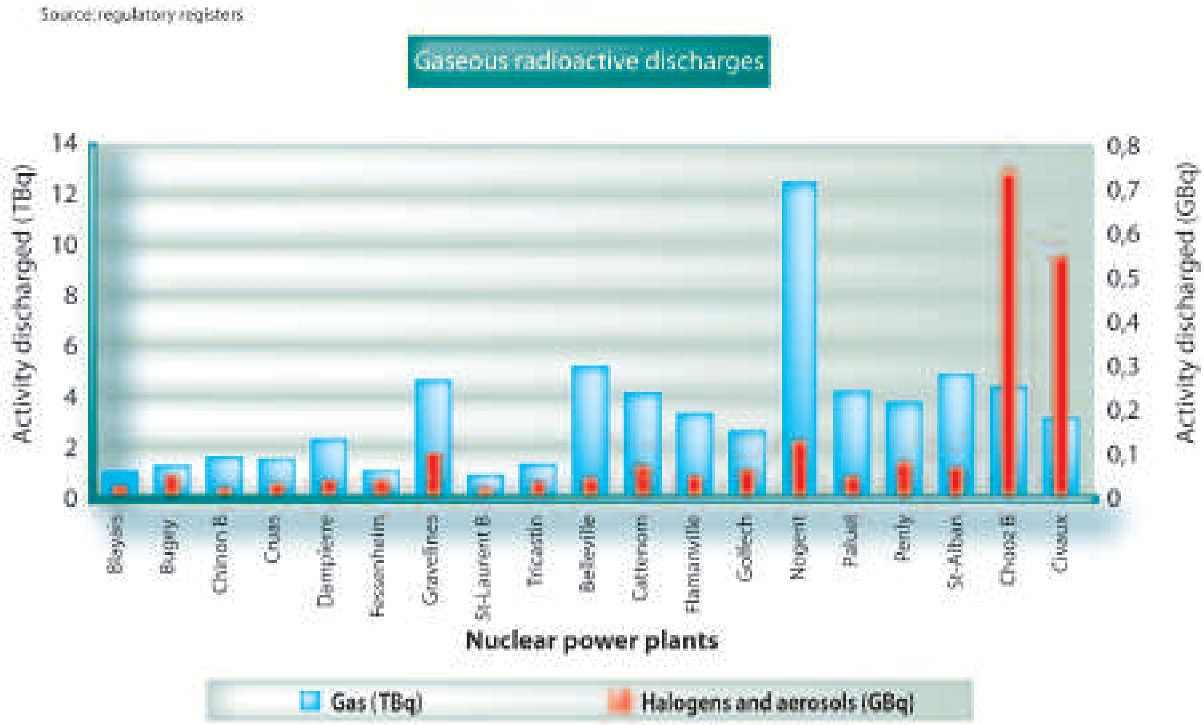
The 2006 results concerning radioactive effluent discharges are presented in the following graphs. The "Liquid radioactive discharge" graph presents the 2006 discharges of liquid tritium and liquid non-tritium (carbon 14, iodine 131, nickel 63 and other beta and gamma emitting radionuclides) per pair of reactors. The "gaseous radioactive discharge" graph presents the 2006 discharge of gases (carbon 14, tritium and rare gases) as well as halogens and aerosols (iodines and other beta and gamma emitting radionuclides) per pair of reactors.

Source: regulatory registers



Gaseous discharges from the Gravelines and Nogent nuclear power plants are in 2006 higher than the "gas parameter" average for their respective plant series (900 MWe and 1300 MWe). This is explained by the higher releases of rare gases (mainly xenon) which are primarily linked to the loss of tightness of the fuel cladding in reactor 2 at Golfech and reactor 6 at Gravelines.

Gaseous discharges from the Chooz and Civaux nuclear power plants are far higher than the "halogens and aerosols" parameter average for the 1300 MWe plant series. This is explained by the higher releases of iodine, mainly due to the loss of tightness of the fuel cladding in reactors 1 and 2 at Civaux and reactor 1 at Chooz.



Radiological impact of discharges

The calculated radiological impact of the maximum discharges in the EDF application dossiers for the most exposed population reference group remains well below the acceptable dosimetric limits for the public.

The annual effective dose received by the population reference group given in the EDF discharge and water intake licence applications is estimated at between a few microsieverts and a few tens of microsieverts per year.

For example, the annual effective dose corresponding to the values requested by EDF for renewal of the discharge and water intake licences for the Nogent-sur-Seine nuclear power plant was evaluated at 23 microsieverts per year. As the actual discharges from the Nogent-sur-Seine nuclear power plant in 2006 were lower than the specified discharge limits, the actual annual effective dose for the population in 2005 is less than this value.

4 | 3

Technological waste management

The nuclear auxiliary buildings (BAN), the waste auxiliary buildings (BAC) and the effluent treatment buildings (BTE) in the nuclear power plants house most of the operations associated with reactor operation and maintenance waste management operations.

The observations made in recent years showed that the safety of waste management in the BAN, BAC and BTE buildings was unsatisfactory in terms of containment, protection against fire risk and radiation protection. At the end of 2002, EDF was asked to correct this situation.

ASN has begun to review the studies forwarded by EDF for eventual improvements in the design and operation of the waste interim storage and treatment buildings in the nuclear power plants. EDF also carried out work to improve these buildings in 2004. The safety analyses concerning these buildings however show inadequacies in the risk assessment owing to the lack of any precise reference system describing the operating range of the waste collection, treatment or interim storage activities in these buildings.

Finally, the series of reviews conducted by ASN in 2005 and 2006 on subjects concerning waste management in the nuclear power plants showed that the licensee was aware that improvements to waste management were really necessary and demanded close supervision of both the installations and the quantities of waste held in them. The actual situation brought to light by these reviews in fact showed that the operating conditions often led to sometimes serious congestion of the installations, for example owing to the problems the sites were encountering in evacuating the waste (malfunction of certain compacting presses, production of nonconforming packages, clearance of the existing stocks). These reviews also revealed the lack of any precise definition of the scope of operation of the activities taking place in these buildings.

In 2006, ASN asked EDF to define a new operational waste management system for its BAN, BAC and BTE buildings in order to remedy this situation and ensure that packaging equipment is available. ASN asked that this management system be based on an exhaustive risk analysis.

ASN will review this new management system in 2007.

4 | 4

Protection against other risks and nuisances

4 | 4 | 1

The microbiological risk

Amoebae

The condenser is a heat exchanger which cools the secondary system with water taken from the river. The older exchangers are made of brass while the more recent ones are made of stainless steel or titanium, which lead to fewer metal releases through wear than brass, which releases copper and zinc. Amoebae do not grow in systems equipped with brass condensers owing to the toxicity for the micro-organisms of the copper present in this material.

In order to comply with the limit value set by the health authorities of 100 Nf/l (amoebae of the Naegleria fowleri type per litre) in the natural environment, the power plants at Bugey, Chooz, Dampierre (reactors 1 and 3), Golfech and Nogent-sur-Seine use monochloramine treatment. Discharges of chemical materials are for their part regulated by government orders which limit the quantities of products discharged. The Civaux plant for its part uses UV radiation treatment of its discharged cooling water owing to the Vienne river's greater susceptibility to chemical treatment discharges.

EDF is also conducting a study programme to look for alternative solutions to chemical treatment.

Legionella

The legionella concentrations in secondary system cooling systems of nuclear power plants with cooling towers are variable and depend on a variety of factors (time of the year, use of anti-amoeba treatment, etc.). They can reach up to several hundred thousand colony forming units per litre (CFU/l - indicating the number of micro-organisms per unit of volume), or even more than a million for those plants with no anti-amoeba treatment: Belleville, Cattenom, Chinon, Cruas, Dampierre (reactors 2 and 4) and Saint-Laurent-des-Eaux. They are less than a hundred thousand CFU/l in Bugey, Chooz, Civaux, Dampierre (reactors 1 and 3), Golfech and Nogent-sur-Seine. The monochloramine treatment used against amoebae thus confirms that it is also effective against legionella.

Legionella concentrations in the large NPP cooling towers

The legionella concentrations not to be exceeded in the secondary system cooling systems are 5.10^6 CFU/l for nuclear power plants with large cooling towers (about 150 m high), and 5.10^5 CFU/l for the Chinon nuclear power plant with its smaller cooling towers (28 m). For systems other than the secondary system cooling system (air-conditioning for example), application of the legal current threshold for ICPEs is required.

Since the end of the summer of 2005, the Chinon nuclear power plant has been equipped with a new monochloramine treatment unit, although this time it is used to treat legionella bacteria. This installation, which required updating of the discharge license, enables the licensee to meet the legionella concentration of 5.10^5 CFU/l.

For the other plants with no specific treatment, the value of 5.10^6 CFU/l is met by the preventive measures normally used by EDF to limit the development of a biofilm (layer of micro-organisms colonising the surface in contact with the water in the systems).

To reinforce prevention of the risk of legionnaire's disease, ASN and the Directorate General for Health (DGS) sent EDF a letter dated 28 January 2005 setting out the maximum legionella concentration levels in the nuclear power plant cooling systems, and the installation surveillance requirements.

At the same time and in liaison with the Directorate General for Health and the Directorate for the Prevention of Pollution and Risks, ASN contacted the French Environmental and Labour Health Safety Agency (AFSSET) in 2004, to obtain its opinion on the assessment of the health and environmental risks linked to the presence of legionella in the nuclear power plant cooling systems. This opinion should help ASN more clearly assess the studies performed by EDF and its general risk prevention and surveillance strategy.

On the basis of an initial appraisal submitted by AFSSET in April 2006, ASN asked EDF to take its analysis further on several points:
- demonstration of the specific nature of the large cooling towers in nuclear power plants as compared with conventional towers, with regard to legionella concentrations in the environment as a result of dispersion of the plume;
- reinforcement of the installations surveillance arrangements;
- review of the means for reducing the growth of legionella in the cooling systems as far as possible;
- analysis of the results of epidemiological surveys.

At the same time, AFSSET is continuing its assessment and in particular its review of the health and environmental impact of additional biocidal treatments that could be utilised to further reduce legionella concentrations.

4 | 4 | 2

Prevention of water pollution

The order of 31 December 1999 sets the general conditions to be met by BNIs concerning environmental protection and requires the performance of work to ensure conformity. A complete description of the provisions of this order is given in chapter 5, point 5|1.

For the special case of the KER/TER/SEK effluent tank leak containments, an ASN decision of 20 April 2006 set 31 July 2006 as the final deadline for their conformity. The conformity work was done on time.

4 | 4 | 3

Noise

The impact of installation noise is regulated: the difference between the ambient noise measured when the installation is operating and the residual noise level measured when it is stopped is subject to a limit and, for example, must not exceed 3 dB(A) at night.

EDF has carried out noise measurements on all the plants. The study showed that ten plants were in conformity while there were nonconformities at Belleville, Bugey, Chinon, Civaux, Dampierre, Golfech, Nogent-sur-Seine, Penly and Saint-Laurent-des-Eaux. The main noise sources are the cooling towers, the turbine halls, the BAN stacks and the transformers.

EDF defined an overall corrective approach based on technical-economic soundproofing studies. For each noise source, EDF looked for partial or total soundproofing techniques and then assessed their effectiveness and technical feasibility. It became apparent that ensuring strict conformity by the nine plants was not possible in acceptable technical and economic conditions, or would imply drawbacks, for example in terms of safety or health.

EDF focused its strategy on three key areas: a reduction and if possible elimination of distinct tones, preferential treatment of noise sources of an industrial nature and, whenever possible, no aggravation in the event of development of the installations or plants. EDF agreed to ensure that the level of protection reached was maintained over time. Furthermore, for sites with cooling towers or a river weir, EDF proposed incorporating their contribution into the residual noise, considering that they are comparable to natural noise from a waterfall.

ASN considers that EDF's approach would be acceptable and that the emergence obtained by incorporating waterfall-type noise contributions into the residual noise correponds to the performance requirements stipulated by the various emergence reduction scenarios. ASN reviewed the technico-economic justifications provided by EDF in order to adopt a stance on each of the sites initially identified as not conforming to the regulations.

5 ASSESSMENT AND OUTLOOK

5 | 1

ASN's assessment of 2006

5 | 1 | 1

General assessment

The following is a summary of ASN's evaluation of EDF's head offices and the performance of its nuclear power plants in terms of nuclear safety, radiation protection and the environment. This evaluation is itself based on the results of inspetions carried out by ASN in 2006, in particular through inspections, regulation of reactor outages and analysing the handling of significant events and incidents by EDF. It is also based on the extent to which inspectors are familiar with the sites they inspect and the head offices. It represents the ASN viewpoint for the year 2006 and helps to guide ASN's regulatory actions in 2007.

Reactor operation

The documents on which operations are based, such as reactor operating and maintenance rules, are on the whole clear and of high quality, and generally well applied on the sites. The EDF engineering departments responsible for drafting the national reference documentation are being reorganised in 2007. ASN will be particularly attentive to maintaining the quality of the documents issued following this reorganisation.

In nuclear power plants, ASN observed differences in the way operating procedures are applied, in supervision of activities and preparation of work and in particular in the drafting of the safety analyses. A lack of rigour would seem to be the cause of these deviations, as was already noted in previous years. Through internal or external audits, the site licensees are aware of their weaknesses on this point and are closely involved in the efforts to move forward, through "operational rigour" type action (improvement) plans and through the "human performance" national project presented in point 2|1|1. ASN considers that EDF must continue its efforts to look carefully at the underlying causes of this lack of rigour.

ASN considers that addition to distributing site licensees are responsive to unforeseen events. They correctly implement the national documentation for incident or accident operations. The local and national experience feedback process is also an efficient means of learning lessons from any incidents that do occur. ASN considers that in addition to distributing incident experience feedback, sharing of good practices between sites should be encouraged.

With regard to firefighting, the efforts made to organise and improve the detection systems have led to faster initial reaction times. However, during exercises, ASN noted that the actual intervention still took too long and it considers that the staff need to be more closely involved in the organisation put into place.

Maintenance activities and subcontractors

In line with its policy of bringing down maintenance costs, EDF is implementing methods particularly aimed at concentrating maintenance operations on equipment for which a failure entails nuclear safety, radiation protection or operational issues. ASN notes that so far, these changes have had no nuclear impact on safety.

However, even if the maintenance management system is clear and of good quality, the site licensees still have problems with keeping up with the rate of document updates required by head office. ASN observes that in 2006, the quality of preparation for maintenance work is still inadequate. The risk analyses in particular need to be conducted more diligently. ASN also considers that EDF needs to improve the intervention conditions on the sites: the inspections carried out on the worksites show that deadlines are always tight and that conventional safety at work requirements are not always met.

Most on-site maintenance activities are undertaken by to subcontractors selected on the basis of an assessment and qualification system concerning which ASN considered no particular comments to be necessary. ASN observed that in 2004, the supervision of subcontractor's activities needed to be improved. In 2005, it observed that progress had been made on this issue, in particular through adoption of national documentation, designed to guarantee improved surveillance. In 2006, ASN noted that this progress was declining and considered that EDF needed to step up its efforts: supervision of and support for the sites by head office must in particular be strengthened and the sites must ensure that adequate resources are allocated to subcontractor surveillance.

Equipment condition

ASN considers that the equipment maintenance and replacement programmes, the safety review process and correction of conformity anomalies identified contribute to keeping the nuclear power plant equipment in satisfactory condition.

ASN however considers that the action initiated by EDF to ensure the long-term qualification of the equipment must be accompanied by adequate management of spares availability and handling of equipment obsolescence, in particular for the older reactors.

• First barrier

ASN is on the whole satisfied with the control of the first containment barrier, in other words the fuel cladding. However, damage or loss of fuel assembly tightness still occurs on most sites despite preventive steps being taken.

In 2006, the main problems encountered were tightness defects occurring during the cycle on a limited number of M5 alloy assemblies and fuel assembly grid deterioration in the primary system.

ASN considers that EDF reacted well to handling the tightness defects. It does however feel that preventing migration of objects and proving that they have no impact on safety need to be further improved.

• Second barrier

ASN considers that the state of the second barrier, which consists mainly of the primary system, could be improved. EDF is paying particular attention to this and is implementing rigorous maintenance programmes. EDF actions concerning the first generation steam generators:
– replacement programme running since the 1990s and targeted maintenance work since 2004 – have led to a significant improvement in their integrity. ASN considers that it is necessary to maintain particular attention on controlling the ageing phenomena affecting the main primary system. ASN in particular considers that the site must be more reactive to leak detection on the primary system and deal with it more rigorously.

ASN also considers that EDF must improve the transcient recording and correction of under-thicknesses on the main secondary systems on its sites.

• Third barrier

The condition of the third barrier, that is the reactor containment, is on the whole satisfactory. Feedback from operation of the single-wall containments of the 900 MWe reactors was reviewed in 2005 in preparation of the third ten-yearly outages. EDF was asked for additional studies, particularly concerning containment in outage states, definition of third barrier extension and the “auxiliary buildings containment” doctrine. These additional studies are currently being reviewed. EDF also proceeded with its 1300 and 1450 MWe reactor containments tightness reinforcement work, scheduled to continue until 2011.

Radiation protection

ASN observed that the active progress being made to improve radiation protection in the nuclear power plants had led to a constant drop in individual and collective worker radiation doses over the past ten years. ASN observed that EDF is learning from international experience feedback, in particular by investigating the feasibility of a “Radiation protection supervision room” project and by developing the second part of the “Source term management” project.

The action plans defined at national level by EDF are being methodically implemented on the sites. ASN did however note that organisational or technical difficulties are preventing the radiation protection approach from being shared by all stakeholders on site.

Consequently, ASN considers that these action plans have not yet fully borne fruit and must be continued and possibly strengthened. Progress still needs to be made in staff attitudes, the quality of risk analyses and application of the principle of optimisation.

The environment

The environmental protection regulations applicable to BNIs have been gradually strengthened. In the field of discharges, ASN has begun a process of systematic revision of the licences issued, for each nuclear power plant. With regard to the prevention of risks and detrimental effects, the ministerial order of 31 December 1999, which applies to all BNIs, was modified by the order of 31 January 2006 which introduces new requirements, particularly with regard to fire risk. ASN notes with satisfaction that these regulatory changes have led to greater concern for environmental protection matters on the part of the nuclear power plants, be it in terms of facility design or operation.

With regard to installation design, EDF has carried out most of the work within the allotted time.

With regard to waste management, ASN observes that following its requests, EDF has reduced clutter on the sorting and interim storage premises through improved management of packaging material availability. On the sites, ASN considers that progress needs to be made in waste sorting, based on the staff training or awareness-raising actions already carried out.

Personnel and organisation

ASN considers that the organisation defined by EDF is on the whole suitable for dealing appropriately with safety and radiation protection issues. Safety is stated as being the top priority. ASN feels that the skills management and qualification system for the reactor operating personnel is satisfactory. In addition, the question of maintaining skill levels was taken on board by EDF, in a context of large-scale retirements scheduled to take place in the next few years.

Manning levels are on the whole sufficient. Reactor outages and surveillance of subcontractor activities are however areas which can be under-manned. A lack of familiarity with safety rules and work-site risks along with tight deadlines sometimes penalise the working conditions. As a whole, EDF must improve how human and organisational factors aspects are incorporated into field activities, in particular in the maintenance sector.

Action plans were implemented to improve stringency in operation and maintenance. The “Human performance” project, currently being deployed, is designed to improve the reliability of maintenance work, allied with greater presence of managers in the field. ASN considers that progress is still necessary, in particular with respect to internal checks, surveillance of subcontractor activities and rigorous application of reference documents. More generally, individual and collective behaviour must better reflect a safety and radiation protection culture.

5 | 1 | 2

Individual site assessments

The following assessment of EDF's nuclear power plants summarises ASN's evaluation of the performance of each site with respect to safety, radiation protection and the environment. This evaluation is itself based on the results of controls carried out by ASN in 2006, particularly through reviews, regulation of reactor outages and analysis of how EDF handles significant events and incidents, as well as on the extent to which the inspectors are familiar with the sites they inspect. It takes account of qualitative rather than quantitative data. It represents ASN's view for 2006 and helps to guide ASN's regulatory actions for 2007. However, the level of safety of a site is not set in stone and can change from one year to the next.

Belleville-sur-Loire nuclear power plant

ASN considers that safety and radiation protection performance on the Belleville-sur-Loire site is generally in line with the assessment made in point 5|1|1.

It feels that the site needs to adopt a more rigorous approach to operations. In 2006, ASN in particular reminded the licensee of the need to adhere strictly to the operating technical specifications

(STE). The in-depth inspection carried out at the end of the year confirmed shortcomings in this field, as well as in the processing of deviations and in organisational matters.

Blayais nuclear power plant

ASN considers that safety and radiation protection performance on the Blayais site is generally in line with the assessment made in point 5|1|1.

It feels that in 2006 the site made progress in operational rigour. However, ASN observed a deterioration in the way in which radiation protection was taken into account during the preparation and performance of operation and maintenance activities. In 2006, it also observed a trend towards a loss of motivation on the part of the firefighting personnel following the transformer fire in 2005.

Bugey nuclear power plant

ASN considers that safety and radiation protection performance on the Bugey site is generally in line with the assessment made in point 5|1|1.

ASN in particular notes the site's efforts in environmental protection and waste management, as evidenced by the implementation of a policy to reduce the production of waste and optimise waste disposal channels. The site is also keen to reduce the interim storage of waste within its perimeter. ASN also considers that the site must be vigilant with regard to the transport of radioactive materials and increase the rigour of the checks and inspections carried out before transport of spent fuel.

Cattenom nuclear power plant

ASN considers that safety and radiation protection performance on the Cattenom site is generally in line with the assessment made in point 5|1|1.

It in particular feels that the site needs to progress in the areas of operational rigour, subcontractor surveillance, preparation of work on equipment important for safety, as well as in training of firefighting staff. In 2007, ASN will focus particularly on these points. Finally, ASN noted that the Cattenom site has made considerable environmental efforts over the past three years, particularly to optimise discharges.

Chinon nuclear power plant

ASN considers that safety and radiation protection performance on the Chinon site is in line with the assessment made in point 5|1|1.

It feels that particular attention should be given by the site to reactor operations in compliance with the STE and to dealing with significant safety events brought to light by improvements in the deviations detection process. ASN also considers that the site needs to improve its worksite surveillance.

Chooz nuclear power plant

ASN considers that safety and radiation protection performance on the Chooz site is generally in line with the assessment made in point 5|1|1.

It feels that the site must make progress in managing technical contingencies, in preparing for maintenance work on equipment important for safety and in handling deviations. ASN also feels that radiation protection on the Chooz site is efficient, even if it needs to improve its dosimetry forecasting.

Civaux nuclear power plant

ASN considers that safety and radiation protection performance on the Civaux site is generally in line with the assessment made in point 5|1|1.

It in particular considers that the site needs to make progress in the field of operations. ASN observed that human factors remain the cause of numerous deviations that occurred in 2006. It feels that the Civaux site will need to continue the efforts already made to take account of human factors, in order to improve rigour in the operation of its reactors.

Cruas-Meysse nuclear power plant

ASN considers that safety and radiation protection performance of the Cruas-Meysse site is generally in line with the assessment made in point 5|1|1.

The site stands out in its management of spare parts and it was designated as one of the seven national management platforms. Emergency situation management was also successfully tested on several occasions, during a national exercise and in a real emergency. However, ASN observed a relaxation of operational rigour, which led to non-compliance with the STE on several occasions.

Dampierre-en-Burly nuclear power plant

ASN considers that the safety and radiation protection performance of the Dampierre-en-Burly site is generally in line with the assessment made in point 5|1|1.

ASN in particular considers that the process to identify and deal with deviations is effective. However, ASN feels that the site must remain vigilant, in particular with respect to application of the operation and maintenance reference documentation. Finally, ASN observed a worsening of the site's conventional safety at work results.

Fessenheim nuclear power plant

ASN considers that in terms of operational rigour, the Fessenheim site is below the level of the overall EDF assessment made in point 5|1|1.

ASN observed deviations in application of the reference documents such as the general operating rules or periodic tests. ASN also considers that the site needs to make progress in post-maintenance qualification of equipment. The action plans put into place by the licensee have not enabled site performance to be improved in these areas.

Flamanville nuclear power plant

ASN considers that the Flamanville site is below the level of the overall EDF assessment made in point 5|1|1 with regard to maintenance and rigorous operation.

ASN considers that the site needs to make progress in the preparation and quality of the maintenance work done on equipment important for safety. It also considers that the site needs to progress in application of the safety documentation, in order to improve rigourous reactor operations.

Golfech nuclear power plant

ASN considers that the Golfech site stands out with respect to its rigorous operational performance in relation to the overall EDF assessment made in point 5|1|1.

The site obtained good results with regard to dosimetry and radiological cleanness, which meant that for the first time in a French nuclear power plant, it was possible to enter a controlled zone in overalls. The site was also reactive to the shortcomings of certain subcontractors, particularly in the field of radiation protection. However in 2006, ASN observed that the site's results had worsened with respect to conventional safety at work.

ASN considers that the site must remain vigilant if it is to maintain its level of results.

Gravelines nuclear power plant

ASN considers that safety and radiation protection performance on the Gravelines site is generally in line with the assessment made in point 5|1|1.

ASN feels that the site needs to achieve greater operational rigour. It also feels that the site needs to make progress, particularly in managing training and in supporting recently trained staff, in preparing maintenance on equipment important for safety and in the rigorous application of the maintenance programmes.

Nogent-sur-Seine nuclear power plant

ASN considers that safety and radiation protection performance on the Nogent-sur-Seine site is generally in line with the assessment made in point 5|1|1.

It feels that the site must adopt a more rigorous approach to operations, particularly concerning compliance with reference documentation and handling of deviations. ASN will remain vigilant with respect to the results obtained by the site in implementing the action plans in these fields.

Paluel nuclear power plant

ASN considers that safety and radiation protection performance on the Paluel site is generally in line with the assessment made in point 5|1|1.

It in particular considers that the site needs to make progress in terms of operational rigour. This field has been identified as an area of progress for the site for a number of years and a specific action plan was implemented. However, ASN is still identifying deviations, in particular during the in-depth inspection conducted in 2006. Finally, ASN considers that the Paluel site is efficient in terms of radiation protection, notably during reactor outages.

Penly nuclear power plant

ASN considers that safety and radiation protection performance on the Penly site is generally in line with the assessment made in point 5|1|1.

It considers that the site stands out with regard to management presence in the field, the management being heavily involved in supervising and controlling human performance. On the other hand, the site still needs to make progress in the quality of pressure vessel management, an area in which ASN has observed deviations with regard to the quality of the equipment supervision and monitoring files.

Saint-Alban nuclear power plant

ASN considers that safety and radiation protection performance on the Saint-Alban site is generally in line with the assessment made in point 5|1|1.

It feels that the site must adopt a more rigorous approach to operations, in particular concerning the quality of the preparation of activities and surveillance in the control room. The site also needs to make efforts in implementing the radiation protection reference documentation.

Saint-Laurent-des-Eaux nuclear power plant

ASN considers that safety and radiation protection performance on the Saint-Laurent-des-Eaux site is generally in line with the assessment made in point 5|1|1.

ASN noted the efforts made in 2006 concerning operational rigour. It nonetheless feels that the site needs to make further progress in this area. ASN noted the large percentage of STE non-compliance occurrences in the significant safety event declarations made by the licensee. Finally, ASN feels that the site needs to make further progress in controlling the installation and managing sensitive transients.

Tricastin nuclear power plant

ASN considers that safety and radiation protection performance on the Tricastin site is generally in line with the assessment made in point 5|1|1.

ASN feels that the site needs to make further progress in particular in the fields of radiological cleanness and when carrying out physical tests on the core. ASN observes that site performance is good in organising pressure vessel supervision and that it takes a proactive stance towards organisational and human factors, in particular by having set up a structure comprising two full-time staff members and a network of correspondents.

5 | 2

Outlook

2006 was marked by important events which will help guide ASN's regulatory work and actions in 2007.

The first is the May 2006 submission by EDF of an application for the authorisation decree concerning the EPR reactor on the Flamanville site. ASN started its review of the preliminary safety case in 2002 at the same time as drafting of this safety case began. It completed its review in 2006, in the light of the safety objectives and directives defined in 2004. The ASN Commission's opinion concerning the reactor project will be forwarded to the Prime Minister at the beginning of 2007. If the authorisation is granted, EDF will be able to begin building the reactor. ASN will for its part begin a review of the detailed engineering studies and initiate a programme of building reviews.

Since 2004, the EPR reactor project has been the subject of cooperation with STUK, the Finnish nuclear safety authority. Since the beginning of 2006, ASN has been involved in the MDEP (Multinational Design Evaluation Program), initiated by the American nuclear safety authority, NRC. This programme, which involves ten nuclear safety authorities, aims to achieve worldwide harmonisation of assessment of new reactors and pooling of resources and know-how, at a time when many new reactor projects are appearing. In 2007, ASN will be continuing its cooperative work, in particular with STUK and NRC, in order to add international points of view to its assessment of EPR reactor safety.

Secondly, at the beginning of 2006, "reference levels" produced by the WENRA association were published as part of its safety harmonisation work, particularly for power reactors. The "reference levels" defined were submitted to the various stakeholders for their comments, in particular the European nuclear power plant licensees. In 2007, ASN will continue to transcribe the "reference levels" consolidated following the consultation process, into regulatory or other official texts. The aim is to reach a harmonised European safety situation in 2010, in accordance with the undertaking made by nuclear safety authorities that are members of WENRA.

With regard to regulation of power reactors, ASN conducted inspections to check the correct working of the "internal authorisations" system put into place in 2005 and which, for operations which do not compromise the safety case, enables EDF to decide on execution without having to ask ASN for prior authorisation. This shifts the burden of responsibility more squarely onto EDF, thereby correcting a natural tendency to leave it up to ASN to check the quality of the files, a task which should above all be the responsibility of the licensee. This also enables ASN to concentrate its regulatory actions on those subjects with more important safety issues. For example, reactor restart after outages involving no maintenance is governed by the "internal authorisations" system. ASN considers that the systems in place are working correctly. However, for the time being, they only cover a very limited scope and could be broadened in 2007.

ASN considers that the state of EDF installations is satisfactory and that the operating methods applied – both maintenance programmes and operating rules – are appropriate. In the fields of radiation protection and environmental protection, ASN considers that EDF obtained results in 2006 that were on the whole satisfactory. However, ASN expects to see further progress in operation and maintenance rigour and in surveillance of activities carried out by the subcontractors. Finally, ASN considers that the conditions on the worksites should be further improved.

Through conformity reviews, a permanent search for anomalies by its engineering departments and the tests and checks carried out during the ten-yearly outages, EDF is attentive to the possibility of generic risks, which are inherent in a standardised population of nuclear power plants. EDF takes advantage of this standardisation in making experience feedback between the reactors more efficient and effective.

It is also important for EDF to continue to take steps to improve safety still further. To do this, the periodic safety reviews are key opportunities for working with ASN. Integration of the changes resulting from the 900 MWe reactors second periodic safety review continued in 2006 and will be completed in 2010. Furthermore, ASN declared itself to be in favour of continued operation of the 1300 MWe reactors following their second periodic safety review. Incorporation of the changes resulting from this review will continue until 2014, when these reactors will undergo their second ten-yearly outages. The periodic safety review of the 900 MWe reactors, to mark their thirtieth birthday, continued in 2006. The question of ageing was looked at particularly closely during this review and ASN asked EDF to present a precise summary of the state of ageing of each of the reactors concerned and to demonstrate that operation could be continued beyond thirty years. The third ten-yearly outages for the 900 MWe reactors are scheduled to start in 2009, and it is on the basis of the results of the checks and inspections carried out on this occasion that ASN will decide on whether or not they will be allowed to continue to operate.

Chapter 12

EDF'S NUCLEAR POWER PLANTS