EDF 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 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, a table at the end of the chapter gives the significant events on each site. Additional information can be obtained from the DRIRE for each individual site.

1 GENERAL INFORMATION ON EDF NUCLEAR POWER PLANTS

Overall, the 19 French nuclear power plants are similar. They each comprise from 2 to 6 PWRs, which all together comes to 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.

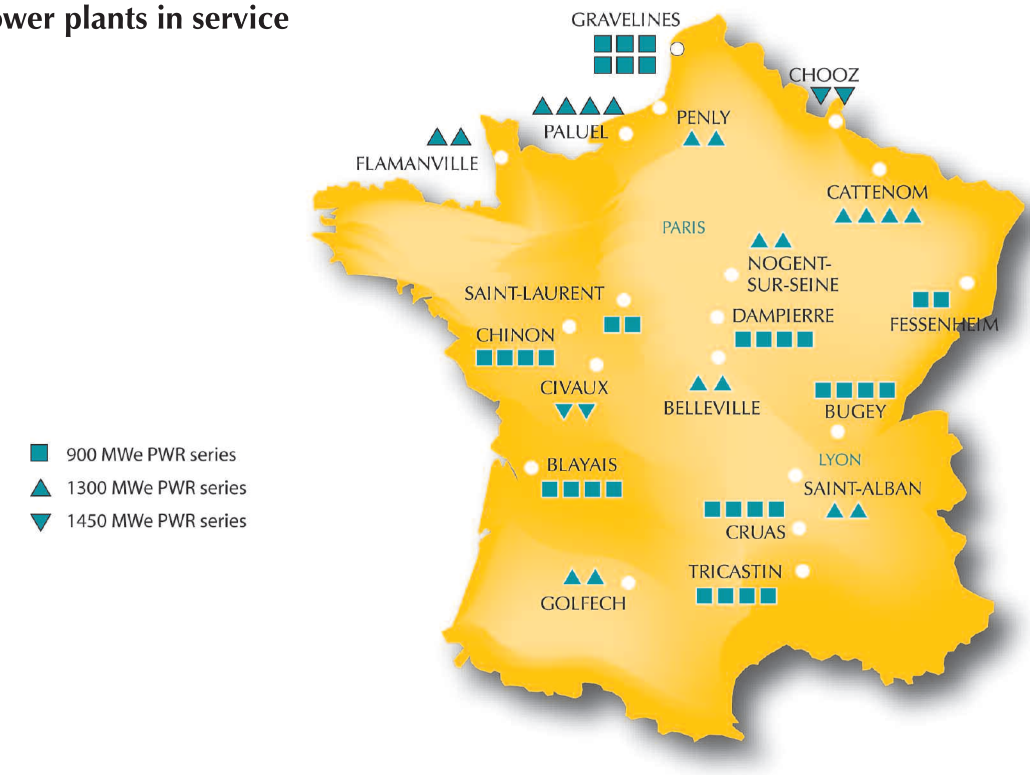
The CPY series differs from the Bugey and Fessenheim reactors in building design and the addition of an intermediate cooling system between that used for containment spraying in the event of an accident and that containing river water, along with more flexible operation.

The design of the 1300 MWe reactor systems, core protection devices and plant buildings differs considerably from CPY series provisions. It will be noted that the power increase is matched by the addition of a fourth steam generator, 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 nuclear power plants in service



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Description of a nuclear power plant

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General presentation 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) and nuclear plants that resulting from the fission of uranium or plutonium atoms. The heat produces steam. This latter is then expanded in a turbine which drives a generator producing 3-phase electric current with a voltage of 400,000 V. After pressure reduction, the steam then flows into a condenser where it cools in contact with tubes containing circulating cold water from the sea, a river or a cooling tower.

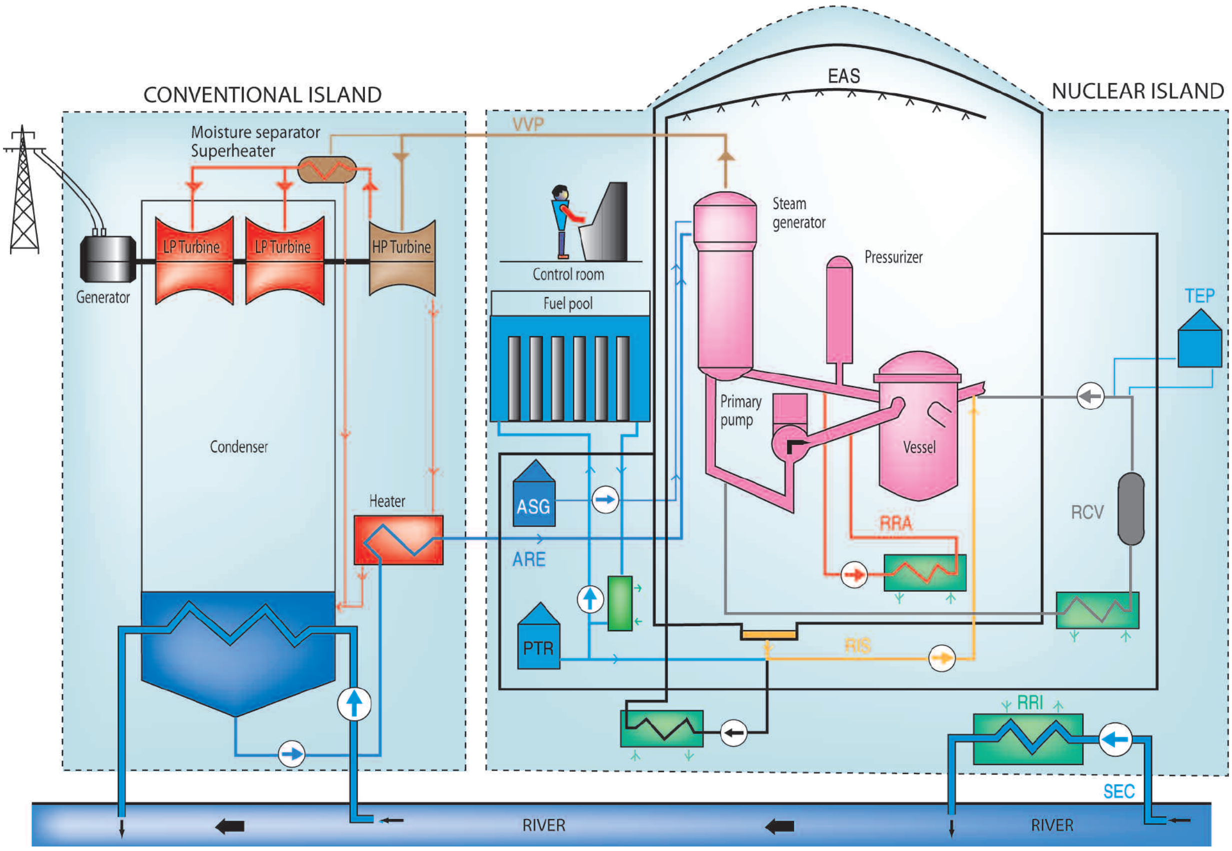
Each reactor comprises a nuclear island, a conventional island, water intake and discharge infrastructures and possibly a cooling tower.

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:

- the rod control cluster assemblies which penetrate the core and contain elements capturing 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 effects 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:

- a uranium oxide (UO_2) fuel initially enriched with U-235. Most of this fuel is manufactured by FBFC, a subsidiary of Framatome and COGEMA. 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 UO_2 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 COGEMA MELOX plant at 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 UO_2 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 are concerned.

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 (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 and secondary systems are used to transport the heat released in the core to the turbine, which produces electricity, without any of the water in contact with the core 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.

In each steam generator, the primary system water transfers the heat produced by the reactor core to the water in a secondary system, without coming into contact with it.

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.

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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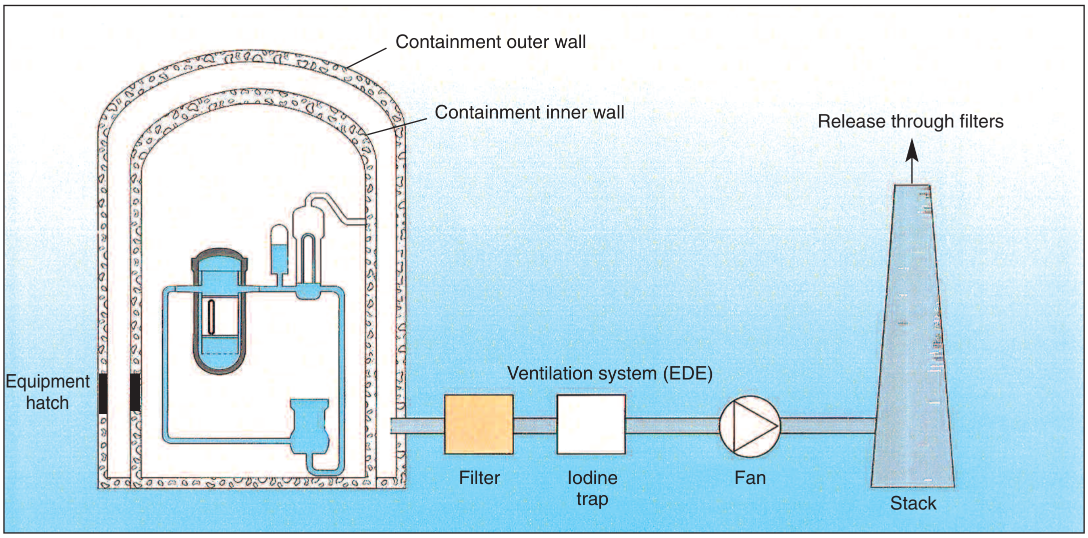
Reactor containment building

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 inside the containment in the event of an accident. The containments are therefore



Block diagram of a 1300 MWe PWR containement building

designed to withstand the pressure and temperature that could be reached in an accident situation, and offer satisfactory leaktightness in such conditions.

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 an external threat. 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 leakage from inside the containment. Resistance to external threats 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. Once the chain reaction stops, the reactor core in fact continues to produce heat for a certain time. This after-power therefore has to be removed to avoid damaging the fuel. The RRA system is also used to drain the reactor cavity after refuelling.

The chemical and volume control system (RCV) is used during nuclear steam supply system (NSSS) operation:
• to adjust the mass of primary system water according to temperature fluctuations;
• to maintain primary system water quality, by reducing the corrosion and fission products content and by injecting chemical products (corrosion inhibitors for example);
• to collect and compensate for normal leakage from the primary pump seals;
• to regulate the boric acid concentration.

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 pumps with varying flow rates and release pressures for different types of accident situations. In the event of an accident, these pumps start by taking in water from a tank of about 2000 m^3, the PTR tank. When the tank is empty, they are 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 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 in the event of failure of the normal feedwater system (ARE). 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 ventilation systems, which play a vital role in containing radioactive substances by depressurising the premises and filtering all discharges;
- the fire-fighting water systems;
- the reactor cavity and spent fuel pit cooling and treatment system (PTR), used notably to remove after-power from irradiated fuel elements stored in the spent fuel pit;
- 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.

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Operation of a nuclear power plant

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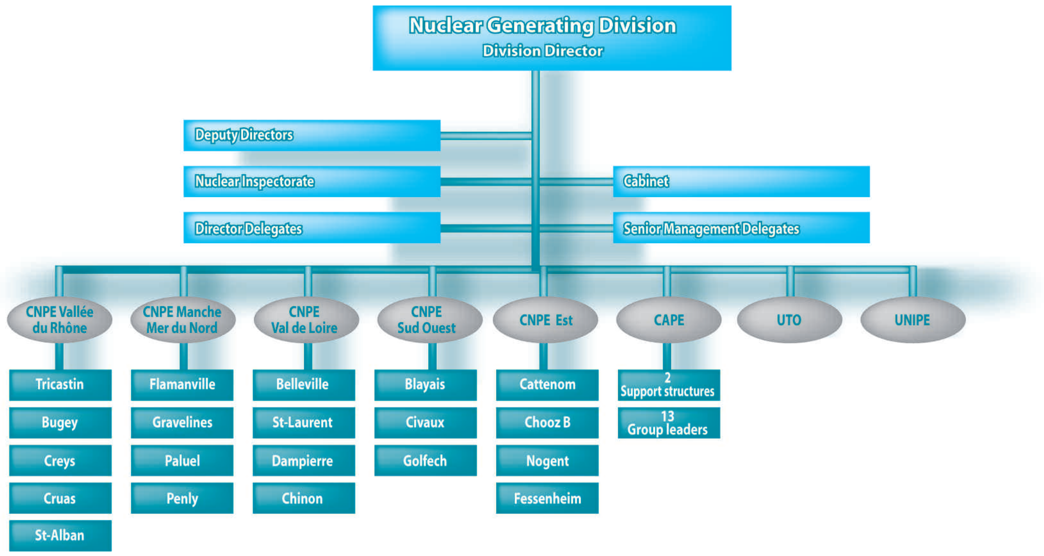
EDF organisational structures

Within the EDF Engineering and Production Branch, created in 2004, a difference is made between the function of operator and that of 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 operator is assumed by the Nuclear Generating Division (DPN). Day to day operation of the nuclear power plants, including safety, radiation protection and security, along with availability and costs, are its duties. 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 implementation of technical decisions. This unit offers expertise in the nuclear energy production trades, including safety, the 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 policy and buying policy. Finally, the IN (Nuclear Inspection) teams, on behalf of the DPN authorities, carry out verification assignments on the entire division.

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.



EDF's Nuclear Production Division's organisation

The roles of owner and designer lie with the Nuclear Engineering Division (DIN). In this respect, the DIN is responsible for the facilities design reference framework. It performs engineering activities 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 operator's work. Finally it has oversight for projects designed to maintain the assets, primarily concerning design aspects, in particular the periodic safety reviews.

Among the 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 supervisory activities at the national level, the Nuclear Safety Authority (ASN) deals mainly with the DPN. The ASN's contacts are the head office departments with regard to generic matters, in other words those that concern some or all of the plants reactors; the ASN deals directly with the plant management for questions specifically concerning their own particular reactors. As regards equipment design and study documents, they are discussed in the first place with the 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 the 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 the ASN.

Chapter 3 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 6 contains the operating rules to maintain or recover safety functions (reactivity control, core cooling, radioactive product containment) under incident or accident conditions and revert to a safe reactor configuration.

Chapter 9 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 10 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 (partial and complete inspections).

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 limited scope programme of verification and maintenance;

Replacing a steam generator

• 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|3).

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. The ASN checks the steps taken by the licensee to guarantee safety and radiation protection during the outage, and the safety of operation during the coming cycle(s).

The main points of the check carried out by the ASN concern the following:
• during the outage preparation phase, the conformity of the reactor outage programme with the applicable reference system. The ASN will give its opinion on this programme;
• during the outage - at the regular information meetings and scheduled, unannounced or post-incident reactive inspections - the handling of the problems encountered;
• at the end of the outage - when the licensee presents the reactor outage summary - the condition of the reactor and its suitability for restart. After this check, the ASN issues the criticality authorisation;
• after criticality, the results of all tests carried out during the outage and after restart.

2 THE NUCLEAR SAFETY AND RADIATION PROTECTION IMPROVEMENT POLICY

The ASN's policy is to ensure that nuclear safety and radiation protection progress and not simply to maintain them at existing levels. This means that the ASN requires that the licensee permanently look for potential areas for improvement and implement these improvements.

This progress can be achieved in two main areas:

- the reactor material status: barring exceptions, the safety improvements affecting equipment are reviewed and implemented during the ten-yearly periodic safety reviews rather than as and when they are conceived, to ensure that the facility is not constantly under modification, which could only be prejudicial to safety;
- the working of the organisations involved in the design, construction or operation of the reactor: they can be the subject of a more continual improvement process.

This policy implies the coexistence of facilities with differing levels of safety, with the safety of the older units being upgraded to keep pace with the more recent ones.

Research is also one source of progress in nuclear safety and radiation protection area.

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Organisations, safety, competitiveness

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Supervision of organisational and human factors

Supervision 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 must be considered at several levels: first of all that of the individual performing a given task (drafting an operating procedure, testing correct operation of a PCB, closing a valve, and so on), or taking a decision. The second level is a collective one (small group, shift team, workshop, etc.), comprising all the individuals concerned by the task (the I&C specialist, his colleague who helps him and the operator who checks the information in the control room). The next higher level is that of the organisational set-up (departments, divisions, units, etc.).

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.

The action of the ASN is therefore based on the following general principles:

- the responsibility of the licensee: within the framework of general safety objectives, it is the role of the licensee 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 its staff. The 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;

N4 reactor control room

• 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: incident analysis should enable the licensee to improve how the working groups function, in other words those groups of staff involved in the performance of a task, such as an operating team. The unsolicited transmission of information should be aimed more at improving safety than looking for a culprit;

• defence in depth: to enable man to play his safety role, human and organisational lines of defence must be set up. These notably consist in definition of systematic technical supervision for sensitive operations, the provision of tactical support for those directly concerned, the detection and treatment of deviations.

In 2005, EDF presented to the ASN its new operational nuclear safety management policy and the policy implementation guide, which was sent out to all sites. This policy interlinks the general safety policy as previously defined, quality management policy and the safety management tools set up by the DPN since 1997 to improve safety and operational stringency in the field.

The observations made during the various checks conducted by the ASN in this area showed that this policy has indeed been deployed on the sites, but not always in the same way. Efforts have been made to improve operational communication, in particular including use of the simulator to train staff in communication, particularly when several departments have to cooperate. Weaknesses nonetheless remain in certain nuclear power plants, for example with risk analysis, which is a tool required by the DPN as part of its safety management policy.

A new operation organisation has also been in place on all sites for several years now. This new organisation is primarily characterised by the creation of the position of Operations Shift Manager and by taking the safety and radiation protection engineer out of the shift team. His assistance and analysis duties are now no longer carried out in real time and he is given an additional verification role. The ASN asked EDF to submit experience feedback on the workings of this organisation in 2006.

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Skills and qualifications management within EDF

With regard to staff training and qualification, EDF policy is now based on decentralising training out to the sites and introducing the notion of competence. This policy gives the nuclear power plants (NPPs) greater freedom of organisation and action and should lead to greater involvement by the local hierarchy in managing skills, in particular through their assessment and by identifying needs.

The programme to deploy a simulator in each nuclear power plant was completed on all plants at the end of 2004. The effect of this should be to increase simulator availability for the operating teams, as well as to offer simulator access to the staff in charge of maintenance or testing. Simulator training now includes situations involving cooperation between several departments, in order to train the staff in operational communication.

As increasing numbers of staff retire, with the corresponding high influx of new personnel, the DPN in 2003 set up a human resources policy giving it a multi-year view of jobs and skills. The goal is to ensure availability of the resources necessary to guarantee the long-term safety and performance of the nuclear power plants.

Since 2001, staff qualification measures have been strengthened through the use of assessments following the national training courses intended for the more sensitive professions. This is already underway for the classroom courses and is gradually being implemented on the simulator courses. The situation with respect to local training courses varies according to the sites.

Overall, the observations made during the various inspections by the ASN in the field of skills management and qualifications show a situation that is satisfactory. However, efforts are still needed in radiation protection and fire training.

The ASN asked the Advisory Committee for nuclear reactors to carry out in 2006 an assessment of the skills management and staff qualification process used by EDF in its nuclear facilities.

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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, concerns 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 (BNIs), the 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.

The use of subcontractors requires that the ASN monitor the following aspects, which also constitute the basis of the “progress and sustainable development charter” signed by EDF and its main contractors.

Choice and surveillance of contractors

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

In 2005, the ASN carried out inspections in all EDF plants and in the head office, focusing on monitoring of work, whether carried out by EDF entities or by outside contractors. It also checked the definition and implementation of a consistent industrial policy designed both to maintain in-house skills in the plants and outsource certain work.

With regard to contractor monitoring, the ASN considers that EDF has made significant progress in the plants, both in preparation and monitoring of the work and in the level of supervision in the field. This progress is to a large extent linked to the approach initiated by EDF head office. However, experience feedback has not yet been analysed concerning working methods and human resources. The ASN will be vigilant in this respect.

Outage activities

With regard to performance and preparation of outage activities, the ASN once again this year confirmed the improvement in early service ordering by EDF and the greater visibility of their workload afforded to the contractors, although EDF's target of 100 % of orders placed 4 months before the beginning of outage has not yet been met.

Radiation protection and conventional safety

In terms of radiation protection for workers involved in outage activities, the ASN focused its attentions on enforcing the Labour Code through inspections conducted during the reactor outages. It 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 person concerned was employed by a subcontractor or by the licensee.

The contractor 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.

EDF has set up a structure for monitoring the contractor market and supervising the available resources. The ASN is keeping a close watch on the subject through its inspections in the plants and in head office.

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Safety and competitiveness

The law 2000-108 of 10 February 2000 regarding the modernisation and development of the public electricity service considerably modifies the domestic electricity market in France. Whilst stipulating EDF's public service commitments, the law, 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 the 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 trends and the new practices implemented or foreseen by the licensee, and on the actions that could be taken by the ASN in this field. The ASN has already initiated work in several areas.

The first area of work is to develop monitoring tools to provide early warning of any drift: the economic situation, spending trends, workforce management and licensee organisational changes are all the subject of closer scrutiny. The ASN has thus questioned EDF about its 2005 budget and asked for a periodic safety and radiation protection summary of certain steps taken to improve the economic performance of the nuclear power plants, such as cycle extensions, or reliability centred maintenance. Spending trends show regular investment in maintaining the nuclear power plants and a more or less constant R&D effort over the period 2002-2005. Overall, the 2005 review showed no worrying drift. However in the future, the ASN will be keeping a close watch on the consequences of any reorganisation within EDF designed to attain its economic performance targets.

The second 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. At the end of 2004, EDF presented these analyses to the ASN to provide a ranking of the modifications currently being defined as part of the periodic safety review for the third ten-yearly outages on the 900 MWe reactors.

The third area of work is to set up a clearer, stronger legal framework. The nuclear safety and transparency bill proposes making improvements to these aspects. Deciding to act immediately, the ASN set up a system of decisions and formal notices and began drafting a number of general technical regulations.

The fourth area of work is to develop international exchanges between nuclear safety authorities, in order to move towards harmonised requirements in the light of licensee internationalisation and the arrival of a competitive, interconnected electricity market. The work done within the WENRA association, in which the ASN plays an active role, contributes to this.

In this context, the Director General of the ASN, in a letter dated 20 September 2005 (available on the www.asn.gouv.fr website), drew the attention of EDF's Chairman to the changes experienced by the nuclear industry in Europe and their short and medium term repercussions with respect to nuclear safety and radiation protection, in particular:

- the growing importance of the international dimension in nuclear safety issues and safety harmonisation work;
- the need for a broader view of safety, including radiation protection and environmental protection concerns, technical aspects, but also human and organisational factors;
- in the context of an increasingly competitive electricity market, the need to preserve the goal of constantly improving safety.

2 | 1 | 5

Internal authorisations

As part of its nuclear installations safety supervision role, the ASN can make certain reactor operations dependent on its prior approval. In certain cases, prior authorisations were imposed on the licensee following significant incidents. Generally however, the 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 the ASN and thereby pay less attention to their quality, which runs contrary to the principle of the licensee's prime responsibility for nuclear safety.

According to experience feedback in recent years, the 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:
• 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, the authorisations in these two areas have been issued by the DPN management or by the management of the plant concerned, after review by an internal commission independent of the decision-making chain and comprising safety and quality experts. EDF also checks the working of these processes and reports on them to the ASN.

During the course of 2005, the ASN conducted an inspection within the DPN to check compliance with the new provisions. In 2006, the ASN will conduct an inspection in each plant on the subject of internal authorisations.

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 the ASN, but also because of the questioning attitude of the licensee, which tracked down these anomalies at its own initiative. The ASN requires that those anomalies with potential safety consequences be corrected within a time commensurate with their significance.

The ASN considers that the checks conducted are the guarantee that a good safety level is maintained and that a facility on which nothing is done to find anomalies would only give the illusion of being safer than one on which the licensee looks for, finds and corrects conformity discrepancies.

Systematic checks: conformity reviews

The ASN requires that conformity reviews be conducted as part of the periodic safety reviews. The conformity reviews consists 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 includes a check on the conformity of the steps taken to protect against external hazards, including extreme weather conditions and earthquakes, and against internal hazards such as high-energy pipe breaks, as well as a check on the ability of the 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 on the 900 megawatt reactors ran from 1997 to 2001, while that for the 1,300 megawatt reactors started in 1999 and ended in 2003.

“Real time” checks

In addition to the process of systematic anomaly searches, a questioning attitude on the part of the licensee’s staff is another means of detecting conformity discrepancies: routine field inspections or even a critical review of older design studies in the engineering centres can contribute to this. Several anomalies were discovered in this way and the ASN considers EDF's attitude in this area to be positive.

Informing the ASN and the public

A specific procedure was set up to inform the ASN about the conformity anomalies discovered by EDF. When there is any doubt as to the conformity of an item, EDF notifies the 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. The 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 the ASN's website.

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

The ASN's remediation requirements

The ASN examines 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.

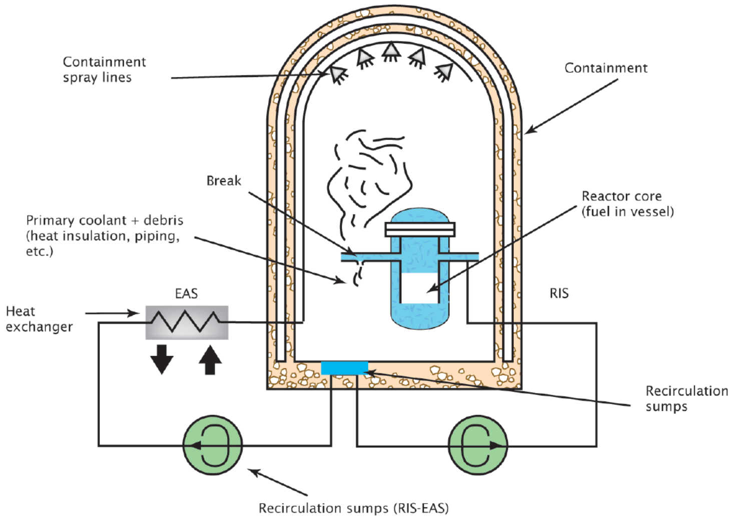
Examples of anomalies currently being handled

– The recirculation sump filters clogging risk

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. These sys-

N4 plant series reactor sumps

tems inject water which is first of all pumped from a tank. When this tank is empty, the water from the leak and the water already sprayed is collected in sumps at the bottom of the reactor building. This water is then reinjected into the primary system by the RIS LP pumps and dispersed into the containment via the EAS system pumps, thus reducing both pressure and temperature.



PWR recirculation function

The main purpose of this reinjection of water into the primary system is to allow continued cooling of the reactor core, thus avoiding a serious core melt accident.

This system is called the recirculation function and constitutes a fundamental "line of defence" in preventing a core melt accident in pressurised water reactors.

Given the flow of water in the reactor building, the debris generated by the pipe break (particles of insulation material, concrete or paint) are likely to reach the sump filters. This results in a risk of sump clogging and of foreign bodies entering the systems, with possible malfunction of the recirculation function. These physical phenomena were indeed taken into account in nuclear reactor design. However, experience feedback and studies conducted at an international level for the past ten years or so have led the ASN to question the pertinence of the rules used for the design of the filtration systems.

According to initial results from the experimental research programme initiated by the IRSN on this subject, the ASN in October 2003 asked EDF for its opinion regarding the risk of failure of the recirculation function, for all French reactor models. In its reply dated 24 December 2003, EDF stated that in certain highly improbable accident situations (complete break of a primary system pipe), clogging of the sump filters could not be ruled out, but that it could be discounted for less serious breaks. All French nuclear reactors are concerned to various extents, with the older ones apparently being the most prone to this phenomenon, as they offer a smaller filtration surface area. The ASN required EDF to review and propose solutions to remedy the anomaly. Given its potential impact on the safety of the facilities, EDF declared a significant safety event on 31 December 2003, rated level 2 on the INES scale, and the ASN issued a press release in early January 2004.

It is worth noting that the anomaly potentially concerns all of the world's pressurised water reactors (the most widely used technology). Some countries, such as Sweden or Finland, consider that they have solved the problem by extending to PWRs those modifications made on their boiling water reactors following the Barsebäck incident. Other countries, such as the United States and France, initially focused their efforts on studying the phenomena and the real impact of the anomaly. After concluding that the anomaly was indeed a potential problem, they are currently working on corrective action.

In order to characterise the anomaly correctly and design a lasting solution, EDF drew up a "studies reference system" which in particular defines the scenarios employed for analysis of the sump filter clogging phenomena. There are many parameters that can influence the phenomena and the physical processes involved are complex, hard to model and as yet insufficiently well understood.

Having received the opinion of the Advisory Committee for nuclear reactors, which reports to it, the ASN in April 2005 considered that additional studies were needed to confirm certain assumptions, but without this standing in the way of a rapid start to the work to correct the anomaly.

As of 2004, EDF began to look at solutions likely to deal with the anomaly. In 2005, EDF replaced the sump filters on three 900 MWe reactors. Experience feedback from this initial work still needs to be analysed before the modifications can be deployed to all the reactors concerned.

Furthermore, while reviewing the design reference system for the EPR reactor, the 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 are currently undergoing technical review, with consultation of the Advisory Committee for nuclear reactors. In compliance with the principle of defence in depth, this review looks at:

- the underlying factors involved in the risk of clogging of the water intakes, in particular the selection of the materials used in the reactor building (choice of heat insulation, paint, etc.);
- the countermeasures which, if conditions are degraded, prevent clogging of the water intakes (sizing of filter surfaces, possibility of filter cleaning by reverse recirculation of water over the screens).

New sumps installed by EDF in 2005

– Anomaly concerning certain EDF 900 MWe reactor safety pumps

On 9 December 2005, EDF informed the ASN that an anomaly rated level 2 on the INES scale had been detected on the pumps of the low-pressure safety injection systems (RIS LP) and containment spray systems (EAS) in the 900 MWe reactors. In the same way as the sump filter clogging anomaly, this concerned the water recirculation function used to cool the reactor in the event of a primary system leak. This anomaly was the subject of an ASN press release on 14 December 2005.

At commissioning of the 900 MWe reactors, vibration of the RIS LP and EAS pumps had been observed. Modifications were made between 1983 and 1987 to attenuate these vibrations and keep them at an acceptable level.

However, EDF took its investigations further in order to gain a better understanding of the phenomena involved and carried out full-scale testing on a test bench, for the first time using water at the same temperature as that liable to be circulating through these pumps in the event of an accident. These tests revealed abnormal vibration of the pump motors, related to the water temperature. More precisely, the vibrations were caused by lifting of the pump motor transmission shaft owing to expansion induced by the temperature of the water circulating through the pipes.

Investigation of the pumps which had been tested showed no signs of damage. However, EDF considers that owing to the high level of vibration, the reliability of these pumps cannot be guaranteed for more than about thirty hours in certain accident situations.

According to EDF, only the pumps on the RIS LP and EAS systems in the 900 MWe reactors are affected by this anomaly, as the 1300 MWe reactor pumps are equipped with a device to compensate for thermal expansion of the transmission shaft, while those in the 1450 MWe reactors use a different technology.

In an accident situation such as that described above, if there is a leak from the primary system, and because of the high temperature of the water circulating through the RIS and EAS systems, the anomaly is liable to cause malfunction of the RIS LP and EAS pumps and thus eventually lead to loss of the recirculation function.

The anomaly has no impact on normal operation of the reactors.

EDF informed the ASN that the anomaly could be corrected, in particular by replacing the pump motor upper bearing by a double-thrust bearing which would prevent the motor rotor from lifting under the effect of thermal expansion. EDF aims to carry out these replacements on all 900 MWe reactors before 31 March 2006.

2 | 2 | 2

Review of experience feedback from reactor operations

At the ASN's request, the Advisory Committee for nuclear reactors in 2005 examined experience feedback from operation of pressurised water reactors over the period 2000-2002. An initial meeting of the Advisory Committee was given over to examination of generic topics. A second meeting was devoted to analysis of topics concerning plant organisation and operating practices.

Investigation of the incidents listed for the period 2000-2002 highlighted the fact that a large number of the significant events was caused by the periodic test programmes. The ASN asked EDF to initiate actions to remedy the weaknesses identified in the periodic test and restart test preparation and performance processes and to submit a review of the improvements resulting from the action taken.

In addition, nonconformity with the technical operating specifications accounts for more than one-third of the significant safety events. The ASN asked EDF to initiate or continue with proactive steps to reduce the number of events involving these fields, in particular to improve how human and organisational factors are considered in the design of the technical operating specifications, and to analyse and monitor any failures to comply with these specifications.

Review of the risk analysis approach and how it is implemented operationally revealed problems with analysing cross-functional risks involving several professions, as well with involving contractors in the risk analysis process. The ASN asked EDF to improve its handling of these aspects as well as its in-depth analysis of significant safety events in order to identify those factors leading to inadequacies in the risk analyses.

Finally, in experience feedback analysis, the ASN wishes to see greater importance attached to studies concerning lessons learned from events occurring abroad.

2 | 2 | 3

Periodic safety reviews

In France, the ASN carries 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 1|2|3) for deployment of these safety improvements.

The review process comprises an orientation phase, setting the topics and scope of the conformity and review studies, a study phase, the aim of which is to determine 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 the ASN. Before the first ten-yearly outage associated with the safety review, the review must rule 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 2005 on the occasion of the second ten-yearly outages at Blayais 4, Cruas 1 and Saint-Laurent B1, 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, the 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, the 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 2008 to 2020.

The twenty-year safety review for the 1300 MWe reactors

Review of the modifications resulting from this periodic safety review was completed in 2005 in accordance with the investigation process established by the ASN.

Implementation of the modifications resulting from this periodic safety review began in spring 2005 during the second ten-yearly outage of Paluel 2. 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 external electricity supply is lost.

2 | 2 | 4

Modifications made to the equipment and to the 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, such as that arising from the 2003 heat wave.

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

For equipment changes, the first part of this process aims to adapt the level of review to the relevance for safety, by classifying the changes in 3 groups according to safety criteria. Only modifications belonging to groups 1 and 2, which have the most pronounced safety impact, require prior ASN approval. The second part of the process specifies the nature of the information the ASN expects from the licensee by stipulating the content and transmission frequency of certain information documents.

In 2005, ASN approvals primarily concerned the balance of the equipment modifications implemented on the occasion of the second ten-yearly outages of the 1,300 MWe reactors and the "commissioning completion package" lot for the 1450 MWe reactors.

Documentary changes are subject to prior approval by the ASN when they affect chapters III, VI, VII, IX and X of the RGE (see 1|2|2). For these changes, the ASN asked EDF to draw up a preliminary note on the safety issues of the main changes to the operating rules.

Since 2004, this has in particular led to an improvement in the time taken to review operating rule changes.

2 | 3

Nuclear power plant ageing

Nuclear power plants, like all industrial installations, are subject to ageing. The role of the ASN is thus to ensure that EDF's general operating strategy takes account of all ageing-related phenomena, in order to guarantee a level of safety compatible with the regulations, throughout the plant's operating lifetime.

2 | 3 | 1

A relatively young population of nuclear power plants

The nuclear power plants currently in operation were built in a very 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 2005:
- the average age of the thirty-four 900 MWe reactors was 24 years (between 18 and 29);
- the average age of the twenty 1,300 MWe reactors was 18 years (between 13 and 21).

The French nuclear power plants are also the youngest of all the plants in the major nuclear countries, with the exception of China.

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 items are therefore subject to close supervision to ensure that their condition and the trends involved are as expected. This is in particular the case with the reactor vessel, sized to withstand the effects of embrittlement due to neutron irradiation of the core zone steel for a period of 40 years (equivalent to continuous operation for 32 years). The reactor vessel is checked by monitoring "control samples" of metal and appraising them at regular intervals.

Deterioration of replaceable items

These are phenomena such as wearing of mechanical parts, hardening and crazing of polymers, corrosion of metals, etc. The equipment requires particularly close attention during the design and manufacturing stages (particularly the choice of materials) along with a monitoring and preventive maintenance, repair or replacement programme as 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 spare 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. Monitoring and preventive maintenance programmes and conformity reviews (see 2|2|1), or review of experience feedback 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, the ministers with responsibility for nuclear safety may at any time ask a licensee to conduct a safety review of its facility. The practice in France is thus to conduct a safety review every 10 years. These reviews are a particularly good opportunity for an in-depth examination of the effects of ageing, but also of the need for and feasibility of modifications to be made if the facility is to keep pace with changes in the safety requirements (see 2|3|2).

In preparation for the 900 MWe reactors third ten-yearly outages, the ASN therefore in 2001 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 reply to this request, Electricité de France drew up a programme of work which was examined by the Advisory Committee for nuclear reactors in December 2003. The organisation set up by EDF under the terms of this programme, and the methodology used to take account of ageing were considered on this occasion to be satisfactory. In 2005, EDF sent the ASN the initial data resulting from implementation of this programme. These data will be 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 examination process, the ASN will adopt a stance for each individual reactor regarding continued operation beyond the third ten-yearly outages.

2|4

The EPR project

2|4|1

The public debate concerning the EPR “first-off” reactor

EDF has stated that it wishes to build a new electricity generating unit using a third-generation nuclear reactor, the EPR, on the Flamanville site (Manche).

In accordance with the Environment Code, EDF referred the issue to the National Public Debates Committee (CNDP) on 4 November 2004. The CNDP decided to hold a national public debate on the EPR project and handed the matter over to a Special Public Debates Committee (CPDP). The aim is to ensure that all the stakeholders concerned (owner, public authorities, elected officials, associations, experts, local residents, general public, etc.) are informed and can express themselves as extensively as possible during the project preparation phase.

The four-month long debate is being held both locally where project construction is planned, and nationally. The ASN is involved in the public meetings held to deal with the various topics. At the end of this debate, EDF will take a decision on whether or not to build an EPR reactor in Flamanville.

2 | 4 | 2

Technical examination

In 2005, ASN review of the detailed studies concerning the EPR reactor project continued apace. The ASN received the opinion of the Advisory Committee for nuclear reactors and the SPN of the Central Committee for Pressure Vessels (SPN) on about fifteen subjects, including:
- worker radiation protection;
- the corium recovery system (core-catcher);
- dealing with heatwave situations;
- design of the rod cluster control mechanisms;
- assumption discounting the possibility of a primary and secondary pipe break;
- steam generator design.

With regard to worker radiation protection, in 2004 the ASN considered that the target was not ambitious enough. The new dossier presented this year by EDF demonstrated a real effort to optimise the work sites which make a significant contribution to the collective dose. This now means that EDF can aim for a collective dose that is significantly lower than the lowest value obtained by the French nuclear power plants in service. At this stage in the design, this point is considered to be satisfactory by the ASN.

With regard to the core-catcher, the ASN considers that the design modifications and additional technical justifications presented are such as to demonstrate correct operation of the system. At this stage in the design, this point is considered to be satisfactory by the ASN.

Concerning heatwave situations, the ASN considers that the design measures for dealing with extreme climatic situations and which take account of the expected climate change over a timeframe of a century, are satisfactory. However, given the uncertainties surrounding this subject in the light of current knowledge, the ASN asked that in addition to the design measures adopted, facilities for in-service adaptation also be designed-in, should actual climate change prove to be greater than originally anticipated.

The planned rod control cluster mechanisms for the EPR reactor are appreciably different from those used in the existing EDF reactors, but similar to those fitted to the German Konvoi type reactors. The manufacturer plans to assemble two stainless steels of different grades to produce the mechanism's envelope structure. The ASN expressed reserves regarding the manufacturer's choice of these materials and the number of welds needed to make each envelope structure.

With regard to the primary and secondary piping, the EPR reactor designer envisages ruling out the possibility of pipe break in the safety demonstrations. The ASN reviewed the demonstration of this "break preclusion" concept, considering that it constituted the first level of a "defence in depth" type approach. On the basis of the SPN's recommendation, it clarified the technical design, manufacture and operational requirements which would confirm the highly improbable nature of a pipe break.

The design choices for the steam generators were evaluated in the light of the new nuclear pressure vessel regulations (see point 3.1 below and chapter 3 point 2|2|1). The design of the EPR reactor steam generators benefits from the experience acquired with the N4 type reactor, the design of which had already taken account of the damage observed on the 900 and 1,300 MWe series steam generators. However, the ASN considers that the data presented at this stage cannot confirm that the geometrical characteristics chosen actually meet the requirements of the new regulations.

The Flamanville nuclear site was chosen by EDF at the end of 2004 for siting of the EPR reactor if it were to be licensed. The ASN is preparing to review the studies concerning specific aspects of the chosen site (seismic activity, flooding risk, design of the pumping station, etc.).

2 | 4 | 3

Cooperation with foreign nuclear safety authorities

After signing a contract with Areva at the end of 2003 for the construction of an EPR reactor, TVO - a Finnish electricity production utility - submitted a construction permit application in early 2004. Construction of the Olkiluoto EPR reactor has begun and the "foundation stone" was officially laid in September 2005. The Finnish and French nuclear safety authorities therefore made the perfectly natural decision to work together closely on this matter. The ASN in particular gave the Finnish nuclear safety authority (STUK) access to all documents dealing with the reviews carried out since 1993 and a Finnish expert was appointed to the Advisory Committee for nuclear reactors.

Several meetings were held in 2005 between the Finnish and French nuclear safety authorities, in order to review the progress of the respective technical investigations on the projects.

The ASN and its technical support organisation, the IRSN, also presented the EPR reactor project and authorisation decree process to the Chinese nuclear safety authority in March 2005 and the Canadian nuclear safety authority in December 2005.

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:
- 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 supervisory organisations know how far a licensee can be pressed to implement safety or radiation protection improvements. The ASN therefore remains abreast of research work in order to make its supervisory actions more pertinent. Moreover, the ability of the supervisory organisations - 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 the 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. The 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. The ASN's findings 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 facilities: for example, EDF's intention to increase nuclear fuel performance in particular generated work on 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.

Finally, the ASN has drawn up an initial inventory of PWR nuclear safety and radiation protection research in France. A significant part of this effort is devoted to serious accidents, in other words with core melt, and the means of minimising the consequences. Conversely, far less research is devoted to human and organisational factors. This research could be boosted given that human factors are still a major contributory factor in incidents.

3 PLANT SAFETY

3|1

Construction supervision

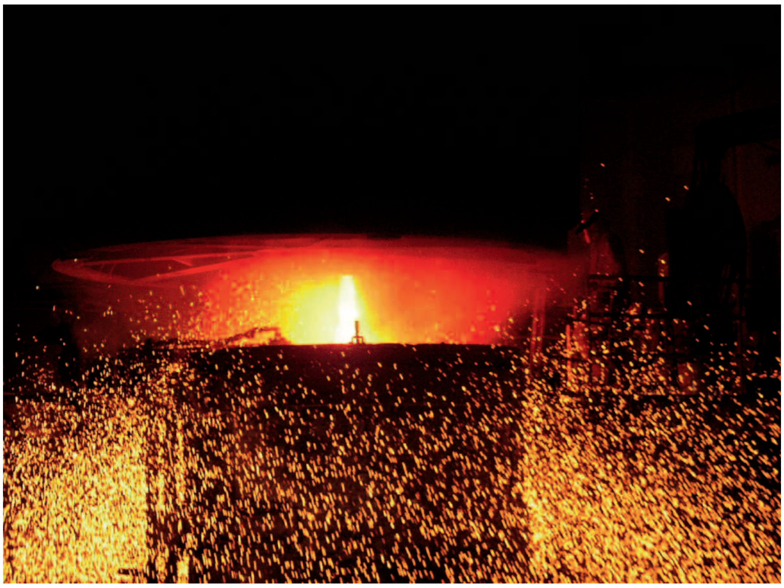
Until the end of 2005, the construction of PWR pressure vessels containing radioactive fluids was regulated by the order of 26 February 1974 and basic safety rule II.3.8 for the main primary and secondary systems and the decrees of 1926 and 1943 for the others (see chapter 3 point 2|2|1). Responsibility for the construction, covering design, industrial manufacture and on-site installation lies with the manufacturer (Framatome ANP or EDF). It is up to the manufacturer to demonstrate the conformity of the equipment it designs. It chooses the manufacturing processes, the checks to be used and the acceptance criteria for the results of these checks. To do this, it usually relies on industrial codes, some of which may be specific to the nuclear industry, in particular the RCC-M code (see chapter 3 point 2|2|3). It is also up to the manufacturer to supervise its suppliers and subcontractors.

Throughout this process, the ASN checks that the manufacturer complies with the regulations and correctly carries out the tasks under its responsibility.

This construction supervision takes place:

- during design, on the basis of the justification files provided by the contractor. 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, their mechanical behaviour in response to these loads, the characteristics of the materials used, the manufacturing processes and their supervision;
- during manufacture/installation: on the one hand prior to the beginning of these operations, based on documents describing the technical options adopted by the contractor, and on the other hand during execution, via checks in the field and in the factory, to ensure compliance with the stipulations of the files concerning equipment dimensions, materials used, manufacturing processes employed and their qualification, the supervision carried out and its results. It ends with hydrostatic testing. The ASN 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.

This process is specific to France, even if in other countries the differences are minimal. For pressurised equipment which is not designed to contain radioactive fluids, there is a European directive which harmonises construction and inspection practices. While maintaining the responsibility of the manufacturer, the directive stipulates essential safety requirements for which compliance must be checked by one of the independent organisations notified by the Member States.



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

With a view to improving safety, while incorporating the technical advances of the directive, the ASN has prepared a new regulatory text. For nuclear pressure vessels, it specifies construction rules and inspection procedures similar to those of the European directive, but which are supplemented to take account of specifically nuclear aspects. This text, an order of 12 December 2005, will apply as of 2006 to the construction of nuclear pressure vessels, in particular those intended for the EPR reactor, should it be built (see point 2|4).

3 | 2

Operation and control

3 | 2 | 1

Normal operating conditions

Technical operating specifications (STEs)

The general operating rules (RGEs) contain the reactor's technical operating specifications (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 in question, 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 the ASN on the basis of safety justifications provided by EDF.

In 2005, the ASN reviewed a number of "amendment documents" modifying the STEs, which were approved or are the subject of additional justification requests. These include:
- an amendment document which concerns the 900 MWe series reactors and aims to modify certain requirements of the STEs to allow a rapid restoration of the national electricity transport grid in the even of a "generalised grid incident" (IRG);
- an STE amendment document concerning the 1,300 MWe series reactors and which aims to meet the ASN's requests concerning risks during reactor outages

The ASN also reviewed the STE revision for the CPY and N4 plant series.

The 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 phase or a maintenance operation, it must apply to the ASN for a waiver, on a case by case basis. The ASN then analyses this request and may accept it, if necessary provided that compensatory measures are taken.

The ASN keeps a close watch over the number of waivers granted. 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 examined in 2005 was 148, or an average of about 2.5 per reactor, per year. The three most commonly evoked reasons for waiver requests in 2005 are linked to:
- the unavailability of reactor systems and electrical sources during modification work or owing to maintenance on the sources themselves;
- unavailability of equipment linked to the safety injection system, as a result of remedial maintenance work;
- maintenance on the nuclear auxiliaries building ventilation system.

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

Field inspection of normal operation

During site inspections, the 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 mid-loop operation (PTB RRA).

3 | 2 | 2

Incident and accident operation

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 applying 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 the ASN.

During 2005, the ASN continued to review changes to the operating rules proposed by EDF and in particular approved:

- the creation of new reactor operating rules to deal with fire situations, called "operator fire action sheets" (FAIOp), for the 1,300 MWe, P'4 and CP0 plant series. Production of the FAIOp operating rules is part of the fire action plan that EDF was committed to implementing on the 900 and 1,300 MWe reactors before the end of 2006;
- a modification to the operating rules in the event of a black-out, to make it easier to restart the reactors and reconnect them to the national electricity transport grid;
- evolution of the N4 series rules, in particular comprising the creation of APE rules for states when the reactor is not closed, in place of the "event-based" rules currently applied.

Generally speaking, the documents submitted by EDF to the ASN for approval are of high quality, even if progress is still needed with respect to the traceability of the origin and the end-purpose of the modifications submitted for approval.

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 2005 highlighted no major issues. Overall, the ASN 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). EDF revised this guide in 2005, primarily to take account of installation of the hydrogen recombiners. The new versions are currently being reviewed by the ASN and its technical support organisation.

In December 2004 and March 2005, for the periodic safety reviews included in the third ten-yearly outages of the 900 MWe reactors, the ASN consulted the Advisory Committee for nuclear reactors concerning the modifications to be made to these reactors in order to improve consideration of the risks associated with serious accidents.

Following this consultation, the ASN in particular asked EDF to install a device to detect corium (mixture of molten fuel and core structure) in the reactor pit on all 900 MWe reactors. The ASN also asked EDF to review the possibility of installing instrumentation for a real-time assessment of the evolving risk of hydrogen explosion in the containment, to help provide data on the progress of the accident.

EDF has also made a commitment to assessing the risks linked to a steam explosion in the event of a vessel puncture in a vessel pit already flooded and, on the occasion of the third ten-yearly outages of the 900 MWe reactors, to install a reliable device for depressurising the primary system, even if electrical power is completely lost.

Finally, and following an ASN request to optimise definition of all serious accident safety requirements, EDF proposed a draft “serious accidents” reference system. This was reviewed by the Advisory Committee for nuclear reactors in 2005. It will need to be revised, particularly to take account of the conclusions of the 900 MWe reactors periodic safety review associated with the third ten-yearly outages, as well as of long-term accident management.

3 | 3 Maintenance and tests

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 disassembling.

A first change occurred in the mid-90s with implementation of the “reliability centred maintenance” (RCM) method. This is the result 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 their causes, as in the previous approach. The ASN considered that this approach did not compromise safety. Further to requests from the 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 standardisation of the NPPs in France, EDF is 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.

The 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 Industrial code changes

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, the ASN observed significant 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, the 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. The ASN will examine implementation of this organisation scheduled for 2006, in particular through inspections.

3 | 3 | 3

Qualification of inspection methods

During the periodic equipment inspections stipulated by the above-mentioned order of 10 November 1999 (see point 1|2|3), the licensee uses "non-destructive testing" to look for possible defects on the equipment and the reactor main primary and secondary systems. International work has come to the conclusion that there is a need for systematic demonstration that these inspection methods are able to detect the types of damage looked for.

Ultrasound inspection of a welded joint

Article 8 of the order of 10 November 1999 specifies that "the non-destructive testing processes employed operationally on the equipment must be qualified prior to use". The same article states that this qualification will be granted by a qualification board set up within the licensee's structure and 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, is accredited by the French Accreditation Committee (COFRAC) and assesses the extent to which the mock-ups used for the demonstration and the defects introduced into them are representative. On the basis of the qualification results, it then confirms that the testing method does indeed achieve the planned level of performance. A description of the qualification process has also been codified in the in-service surveillance rules for mechanical equipment (RSE-M): as applicable, the aim is either to demonstrate that the inspection technique used is able to detect a degradation described in specifications, or to explain the performance of 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 also granted transitional periods of varying lengths for implementation of their respective programmes.

In France, the decision was taken to apply this qualification process to all non-destructive testing procedures used in the main primary and secondary system inspection programmes. This today represents 144 applications which, given their technical similarities, are covered by 76 qualification files.

The large volume of demonstrations linked to these files and the technical difficulties involved, led EDF to ask for additional time for certain files and to propose palliative measures. After analysis of these proposals and on the advice of the Central Committee for Pressure Vessels, the ASN agreed to postpone the deadline to 31 December 2005, with these particular files being the subject of particular scrutiny.

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 2005, the 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;
- review of changes to the periodic test programmes associated with the second ten-yearly outages for the 1300 MWe reactors;
- review of changes to the periodic test programmes for the 1,450 MWe reactors with "PTD end of series" status.

The 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. The 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 the ASN.

EDF plans to use M5 alloy in place of Zircaloy 4 alloy as the cladding and structural material for the fuel assemblies in all the new types of management. In 2005, the ASN sent EDF a number of preconditions for generalised use of M5 alloy in all nuclear power plants.

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 UO_2 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 2005, the ASN continued to investigate the following aspects of this type of management: normal operation, accident studies, incident and accident operating rules, refuelling safety.

GALICE

As of 2006, 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.

Preparation of the safety analysis file for this type of management has been postponed by EDF.

ALCADE

ALCADE management is envisaged 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.

Analysis of the feasibility file was completed in the summer of 2005. As with GALICE management, it showed that the justifications for a certain number of points related to the nature of the fuel rod cladding material were still inadequate and that the loss of coolant accident (LOCA) study method required further examination.

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 fuel cladding

In 2005, the ASN authorised burnup of a load of AFA3GLrAA fuel (clad and structure made of M5 alloy) in several reactors (Cattenom 3, Nogent 2 and Civaux 2).

A certain number of questions concerning the loss of coolant accident, pellet-clad interaction and the impact of M5 on the fuel cycle will require answers from EDF before this type of assembly can be deployed for general use.

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. In 2005, the ASN authorised the introduction of new RFA fuel loads in six 900 MWe reactors. The four reactors already authorised in the past introduced their second refuelling load.

Rod cluster control assembly drop time

Since 2002, fuel assemblies with a reinforced structure (see above) have gradually been introduced into the reactors by the licensee, in order to limit irradiation induced deformation and improve the overall RCC assembly drop time. Based on this favourable experience feedback, the ASN in 2004 relaxed the requirements concerning measurement of the RCC assembly drop time during the cycle.

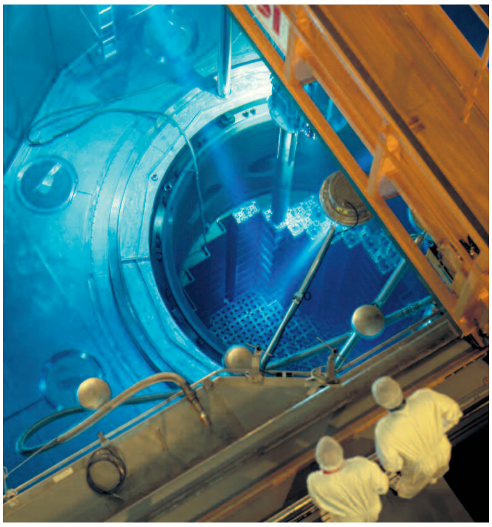
This favourable trend continued and in 2005, the ASN authorised the licensee to load fuel under RCC assemblies during their final irradiation cycle and put an end to the obligation to carry out RCC assembly drop time tests during the course of the cycle. Requirements concerning RCC drop time tests at the end of the cycle and the particular fuel assembly deformation measurements are for their part maintained for all reactors in order to consolidate experience feedback.

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 pit and that in the reactor building, so that they can be positioned in the reactor vessel in accordance with predetermined reloading sequences.

Since the loading incident at Dampierre in 2001, EDF has gradually implemented measures designed to improve the organisation and monitoring of handling operations and licensee criticality risk training.



Fuel handling in vessel

Implementation of the initial measures was not in itself enough to prevent further positioning errors involving a few assemblies, so in 2004 the ASN once again asked EDF to bolster its provisions for preventing fuel assembly positioning errors in the reactor.

At the beginning of 2005, EDF took additional steps, in particular to ensure that each fuel assembly is pre-positioned at the correct location in the reactor before it is actually reloaded. Furthermore, the organisation of the teams in charge of fuel handling was modified in order to further reinforce the checks on correct performance of the fuel reloading operations. Finally, surveillance of criticality risk control was redefined in order to anticipate the risk of primary coolant dilution during fuel handling operations in the reactor.

These measures meant that the fuel handling operations performed in 2005 were 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 the 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.

In 2005, the ASN's actions primarily concerned assessment of the EDF demonstration of the 900 MWe reactor vessels' service life. On the whole, the 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 will 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. For reactors already in operation at the time the order was published, a time was allocated for compilation of these files.

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. In 2005, through inspections or meetings, the ASN was able to check that nearly all the plants had set up an organisation and created a plan of actions for compiling and updating these files.

In May 2005, the ASN asked the Standing Nuclear Section (SPN) of the Central Committee for Pressure Vessels for its opinion on the first part of the "plant series" reference files. The SPN considered that on the whole these files were satisfactory but did state that additional data was needed. EDF will in particular be required to guarantee that the operating parameters considered encompass all possible values, and to classify the system zones with respect to the risk of fatigue or sudden failure. These data will need to be provided in time for the next maintenance document update.

ASN review of a second part of the reference files will continue in 2006.

Situations counting

The purpose of situations counting is to ensure that the NSSS design margins are maintained throughout the life of the reactor.

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 record in its documentary system those situations effectively encountered by the systems.

Counting of these situations is important to the ASN because it is a key factor in demonstrating the robustness of the equipment over its entire lifetime. The ASN carries out periodic inspections on this subject. The points tackled concern plant organisation, verification of activities, records and associated resources, archival, experience feedback, situations counting contractors, etc.

The ASN considers that this situations counting activity was not sufficiently stringent until 1997, at which point it asked EDF to take corrective measures. In 2002, the ASN began a tour of inspection, to be completed in 2006, to obtain an overview of how EDF now carries out this situation counting. The ASN has already observed an improvement but considers that further progress is still required. The level of quality differs from one site to another and much could be gained from harmonising the practices employed.

3 | 5 | 2

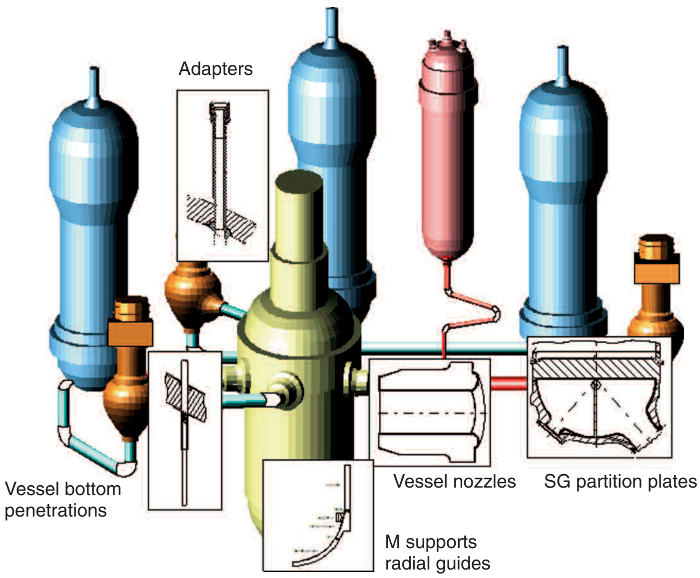
The use of nickel-based alloys

Several parts of PWR reactors are made of nickel-based alloys: in the steam generators, the tubes, the partition plate, the coating of the primary side of the tubesheet; in the vessel, the vessel head adapters, the vessel bottom head penetrations, the internals lower guide support welds, the repaired 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.

The ASN asked the licensee to adopt an overall surveillance and maintenance approach for the zones concerned. Further to its decision 010067 of 5 March 2001 (available on the www.asn.gouv.fr website), a number of main primary system zones made of Inconel 600 alloy are now subject to particularly close inspection. 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 3|5|3 and 3|5|4).

In 2004, cracks attributable to stress corrosion were discovered on the partition plate in a steam generator which hitherto had not been considered by EDF to be susceptible to this type of damage. The ASN therefore asked EDF to adapt its maintenance strategy to take account of this unexpected damage. EDF made a number of commitments, in particular to develop automatic tools for inspecting and repairing these zones more easily. This was partially completed in 2005. A process for ultrasound characterisation of crack geometry was developed and deployed on several steam generators for a trial period.

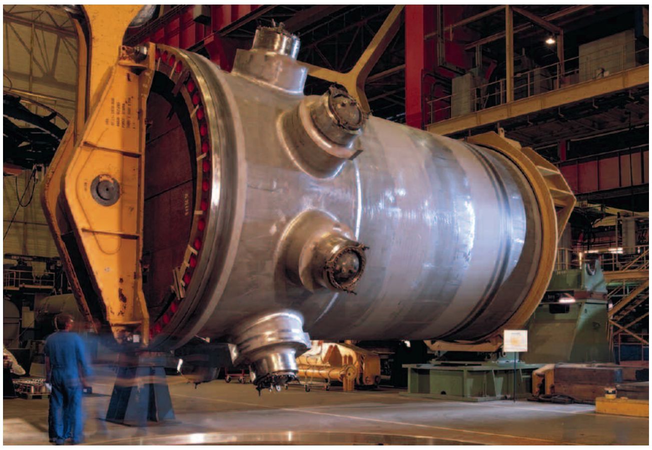


Inconel alloy zones on main primary system

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 bars at a temperature of 300 °C.



Vessel being manufactured

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.

In normal operation, the vessel gradually deteriorates as the neutron radiation from the reactor's fissile core embrittles the vessel 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 against 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 extracted and subjected to mechanical testing. The results of these tests give a good picture of how the vessel metal is ageing, and in fact even give advance "early warning" as the capsules are situated close to the core and receive more neutrons than the actual vessel itself;
- periodic ultrasonic testing: this check is used to monitor any defects located under the vessel's inner stainless steel lining.

The 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.

The ASN however thinks 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 examined and which was reviewed by the SPN's experts during its 18 October and 13 December 2005 sessions.

Following this examination and in the light of the results of the checks carried out during the reactors' third ten-yearly outage, the ASN will define its position regarding the vessel operating conditions beyond 30 years.

3|5|4

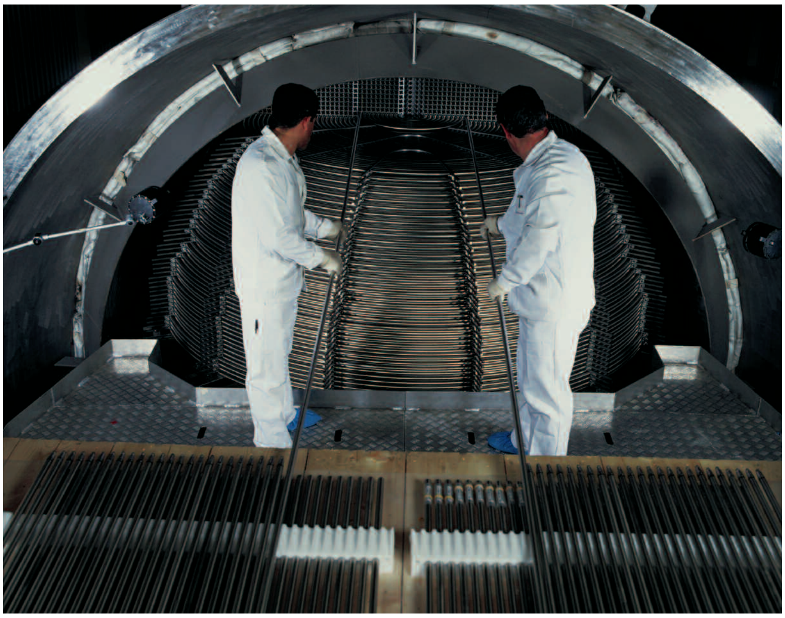
Steam generators

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 reviewd by the ASN in 2003 and accepted by DGSNR decision n° 030472 on 1 December 2003 (available on the website www.asn.gouv.fr). 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. In 2005, the steam generators at Dampierre 2 were replaced and currently twelve of the first thirty-four 900 MWe reactors are still equipped with Inconel 600 alloy steam generator tube bundles which were not heat treated (600 MA), and which are the main victims of stress corrosion induced cracking (see point 3|5|2).



Installing tubes in a steam generator being manufactured

In addition to in-service surveillance, the steam generators undergo a hydrostatic test every 10 years: during the reactor ten-yearly outage (see point 3|2|3), the primary system undergoes an overall pressure test subjecting it to a pressure higher than 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 (see chapter 2, point 2|1|5 b), the 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.

In 2006, EDF also launched a 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, to gain a clearer understanding of their performance during the hydrostatic test and determine how to avoid leaks during the tests.

3 | 5 | 5

Main secondary system protection valves

Each main secondary system (CSP) on the EDF reactors is protected by seven safety valves installed on the main steam lines. Apart from their CSP protection function, these valves also constitute one of the limits of the third containment barrier.

Since the 1990s, cracks have been discovered on certain CSP protection valve nozzles. After carrying out a series of investigations – mainly on the Paluel site, which was the most seriously affected by this type of damage - EDF proposed a maintenance strategy comprising in-service checks, installation modifications and a programme to repair the damaged valves.

These justifications were submitted to the experts in the SPN of the Central Committee for Pressure Vessels during the first quarter of 2005.

The SPN considered that the maintenance and in-service inspection strategy proposed by EDF for the nuclear power plant CSP valves, and in particular those at Paluel, was acceptable provided that a certain number of recommendations were taken into account.

The main recommendations, reiterated by the ASN, are as follows:

• maintaining a valve complete inspection interval of 7 years, as in the programmes currently in force;

• scheduling repair of damaged valves as rapidly as possible according to the availability of repair resources and the availability constraints associated with these devices.

3 | 6

Containment

The containments undergo inspections and tests with the aim of checking that they indeed meet the safety requirements and in particular that their mechanical performance is satisfactory and guarantees correct tightness when the pressure in the reactor building is higher than atmospheric pressure, which can be the case in certain types of accidents. These tests, particularly at the end of construction and then during the ten-yearly outages, include a pressure rise up to the inner containment design pressure.

Flamanville (Manche) nuclear power plant

The containments of the 900 MWe reactors consist of a single wall of pre-stressed concrete with an interior metal liner. Until now, the leak rates from these containments during the ten-yearly inspections were in conformity with the regulatory criteria. Their ageing was reviewed in 2005 as part of the 30-year periodic safety review, in particular with respect to 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 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 take account of 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 of the Advisory Committee for nuclear reactors which met to discuss the subject in early 2002, the ASN gave EDF its approval of this strategy. This work is done at each ten-yearly outage and by the end of 2005, 18 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 the ASN.

Updating of the design rules

After the 2001 update of the basic safety rule covering how to determine the seismic risk for the safety of surface BNIs (RFS 2001-01), the ASN in 2005 continued its work to update the RFS dealing with the construction rules to be used to protect against the effects of an earthquake (RFS V.2.g). The current rule dates from 1985 and the new data available in this area must be taken into account.

This new "seismic design" guide will detail the main steps in the design of the civil engineering structures with regard to earthquakes, from a statement of the basic principles underpinning this design, to determination of the spectra to be used for sizing of the equipment anchored to the civil engineering part. It will apply to all surface BNIs. A draft guide will be discussed at a meeting of the Advisory Committees in 2006.

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, the 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). To date, these studies have shown no need to reinforce the buildings. For the reactors of the CP0 series, the ASN asked EDF to study the seismic design of the nuclear island buildings and the turbine hall.

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

Further to flooding of the Blayais site in December 1999, EDF undertook steps aimed at reassessment and protection of the sites against external flooding hazards. This reassessment particularly concerns the revision of the maximum design flood level, or CMS (maximum water level used in the design of the plant protection structures), the additional events which could lead to flooding of the sites, such as particularly heavy rainfall, a break in the water storage tanks, a rise in the water table, as well as the course of action to be followed in the reactors if the water level were to rise. 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. In particular, the building permit for a peripheral protection dyke around the Belleville plant was issued and construction should begin in the first quarter of 2006. Construction of a peripheral wall around the Bugey site is also in progress and should be completed at the end of 2006.

Protective dyke surrounding the Le Blayais plant (Gironde)

The ASN considers that the progress of studies and work is as expected. Nonetheless, for the particular case of the Tricastin NPP, the CMS review studies are not yet complete. Additional studies to check the strength of the infrastructures located on the Rhone river upstream of the plant are nearing completion. The results of these studies are expected for early 2006.

At the end of 2004, the ASN asked the Advisory Committee for nuclear reactors and the Advisory Committee for laboratories and plants for their recommendation in order to rule on the overall approach to the external flooding risk affecting EDF reactors. The situation of the other nuclear installations will be reviewed on this same occasion, which justifies a joint meeting of the two Advisory Committees.

At the same time, a first meeting of the working group for revision of RFS I.2.e to deal with the flooding risk, was held in 2005. This group consists of experts, licensee representatives and the 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 apply to all BNIs.

3 | 7 | 3

Fire and explosion riks

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, 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.

The ASN has noticed improvements since 2004 in the drafting of the fire permits and their actual use in the plants. It does however feel that the steps taken must be actively pursued, in particular with respect to risk analysis and identification and implementation of protective measures.

In 2005, the ASN checked the progress of the work being done to identify the areas storing fire loads during reactor outages and will analyse all the corresponding studies with the assistance of its technical support organisation. Inspections will be scheduled by the ASN in order to check the conditions in which these premises are used.

Design

With regard to design, EDF is continuing to deploy the fire action plan (PAI), to ensure the conformity of and improve fire protection for the 900 MWe and 1,300 MWe reactors. During the course of the 2005 inspections and six-monthly meetings with EDF, the ASN considered that the PAI was being satisfactorily assimilated and that EDF was on-track to meet the completion dates set for the end of 2006 by the decision of 12 September 2000.

As part of the thirty-year safety review of the 900 MWe reactors, the ASN in March 2005 consulted the Advisory Committee for nuclear reactors about the modifications to be made to these reactors in addition to the current design:
• through the use of the results of fire probabilistic safety studies (EPS), to supplement the deterministic studies,
• through evaluation of the existing design margins of the fire-resistant items, in the light of the fire durations estimated for the premises.

The ASN considers that the results of the probabilistic studies are satisfactory and that the fire EPS approach should be continued by EDF for the 900 MWe reactors.

Furthermore, with regard to evaluation of the existing margins, the ASN considers that the modifications presented by EDF would be such as to improve the safety of the 900 MWe reactors. EDF will complete its evaluation by ensuring that the inventory of premises checked is exhaustive and that there is no snowball effect in relation to the margins chosen.

The order of 31 December 1999 which lays down the general technical regulations designed to prevent and mitigate detrimental effects and external risks resulting from the operation of BNIs, also defines stipulations regarding fire protection. In 2005, the ASN drafted an application guide for the above-mentioned order dealing with the fire risk and prepared a draft order modifying and improving the previous one.

Firefighting

With respect to firefighting, the ASN asked EDF in May 2001 to conduct an overall review of its policy. In response to this, EDF developed a new doctrine, which it put into practice in July 2003. The ASN duly noted this change and considered that it offered a better answer to what it wanted to see in terms of firefighting. It reckons in particular that the part about increased skills is just as important as that concerning organisational improvements.

At the request of the ASN, EDF further reinforced its doctrine in 2004, in particular by aiming for faster activation of the response teams as of the fire alarm, rather than after the fire has been confirmed. On certain sites, this will require drafting of a fire detection improvement plan. This plan is being gradually put in place as of 2004.

In 2005, the ASN reviewed the effectiveness of the plan of action proposed by EDF for deployment of this new doctrine and improvement of the reliability of fire detection. It considers that the firefighting response times have progressed on those sites which immediately deploy the response teams as soon as the alarm is sounded but that EDF does still need to focus on the actual duties of the response teams and on improving interfacing with the off-site emergency services.

In 2005, the ASN also ordered an assessment of the firefighting team response from an independent firm. It will include the conclusions of this assessment in the requests it submits to EDF in 2006.

Explosion risk

On the basis of the conclusions of the 2002 inspections on this subject, the incidents and the anomalies detected in the plants, the 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 Chinon in-depth inspection on the topics of fire and explosion

Further to the inadequacies detected during the inspections carried out in 2003 and 2004 on these topics, the ASN carried out an in-depth inspection on fire prevention and firefighting on the Chinon site, from 7 to 11 March 2005. During the course of this inspection, the ASN had fire exercises performed, one of which involved participation by the *département* fire and emergency services (SDIS) with activation of the on-site emergency plan.

This inspection was equivalent to about fifteen "routine" site inspections.

As a result of its investigations, the ASN observed that EDF had made efforts to reduce the fire risk, to improve response team training and to reach the goals associated with their duties on this site. However, it considered that continued efforts were required, in particular by improving the stringency of fire risk management and the application of fire doctrines..

In-depth inspection at Chinon, March 2005

The methodology developed by EDF, and in particular the application of this methodology to the hydrogen-related risk of internal explosion within the nuclear island buildings was analysed in 2005 by the Advisory Committee for nuclear reactors.

With regard to the risk of explosion originating outside the buildings, the 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.

Furthermore, with regard to the risk of explosion originating inside the buildings, EDF should complete its studies with review of gases other than hydrogen and by extending its analyses to buildings other than the reactor buildings.

In 2005, EDF continued to draft the studies reference system concerning the prevention of explosion risks, and the ASN has already formulated a number of remarks concerning it. The goal is for this reference system to be applied to the 900 MWe reactors' third ten-yearly outage.

3 | 7 | 4

Other hazards

Lightning

Further to the ASN request of 15 October 2002, EDF forwarded the "lightning studies" defining the work needed before 31 December 2003 to ensure conformity with the above-mentioned order of 31 December 1999. EDF also completed conformity work on the plants concerned (Penly and Cruas) on 31 December 2004.

The ASN notified EDF of its additional requests, including a study of the impact of the lightning risk on the safety of the facilities. The ASN considers that the lightning risk studies transmitted by EDF are of high quality and in conformity with the applicable standards.

Heavy loads carried over the reactor vessel

During exceptional maintenance operations such as vessel head replacement and more conventional maintenance operations such as "tightening-loosening" vessel studs, handling of associated elements may require them to be carried over the vessel with the core loaded. These operations may also take place with the containment's equipment hatch open. The general operating rules (RGE) prohibit fuel handling when the reactor building is not correctly isolated from the outside.

At the request of the ASN, EDF conducted on all its nuclear power plants an analysis of these cases of equipment being carried over the loaded core vessel, whether or not the vessel head is in place. The analysis looked at ways of limiting these movements and, for those which remain necessary, how to prevent a load dropping and if it did, minimising its consequences.

The conclusions of this analysis led EDF to modify its practices to limit these handling situations and to submit a proposal to the ASN for modification of the general operating rules, particularly in order to define containment configurations for which these load movements over the reactor vessel remain authorised. Review of this subject began in 2005. The ASN asked EDF to apply additional constraints for certain types of load handling operations.

Heatwave and drought

Following the heatwave EDF had to deal with in 2003, steps were taken to ensure an appropriate response to any similar situation during the summer of 2004. 2005 was marked by a severe drought, although this had no safety or environmental protection consequences as a result of discharges from the nuclear power plants.

In 2005, in compliance with requests for changes to the general operating rules, EDF reassessed the maximum temperature limits allowable in premises containing equipment important for safety. Some of these requests are still being reviewed and the licensee will be required to submit additional safety justifications. The renewal of the discharge and water intake licence for the Nogent-sur-Seine nuclear power plant at the end of 2005 was also an opportunity to include the possibility of higher temperature discharges in certain climatic and power demand conditions, as with the Bugey, Golfech and Tricastin NPPs.

3 | 8

Other subjects

3 | 8 | 1

Pressured 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, pressurised equipment entails risks that must be controlled.

This equipment (containers, exchangers, piping, etc.) is not solely limited to the nuclear industry and is present in numerous industries such as chemical industry, oil processing, papermaking, refrigeration industry. 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.

Application of the regulations concerning the operation of pressurised equipment in nuclear reactors is monitored by the ASN. In particular through actions on the site, this consists in checking that the licensee, who has prime responsibility for the safety of its equipment, applies the requirements imposed upon it. It must in particular:

- collect and update the information needed for safe operation of its equipment;
- maintain, monitor and repair as required to ensure that the safety level of its equipment is as required, and conduct the periodic inspections at the specified intervals on the relevant equipment;
- remove from service equipment for which the safety level is impaired;
- install and maintain protective devices designed to ensure that the maximum temperature and pressure limits are not exceeded during operation;
- submit the relevant equipment to periodic re-qualification (inspection, testing and check on safety accessories) and to inspections following significant repairs. These operations must be carried out by duly qualified independent bodies.

The ASN also examines any request for waiver to the regulations and supervises the qualified bodies intervening in the NPPs. It is represented on the Central Committee for Pressure Vessels (see chapter 2, point 2|1|5 b) and in this capacity takes part in the drafting and updating of the pressure vessel regulations.

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.

Verification of application of these regulations is the job of "labour" inspectors who, in the particular case of nuclear power plants, operate within the DRIRE and for the most part are also inspectors of BNIs. The inspections in this area are carried out in accordance with the directives of the Directorate for energy demand and energy markets of the General Directorate for energy and raw materials (DGEMP).

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;
- 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).

The ASN considers that this process, which has been in progress for 6 years, is now 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.

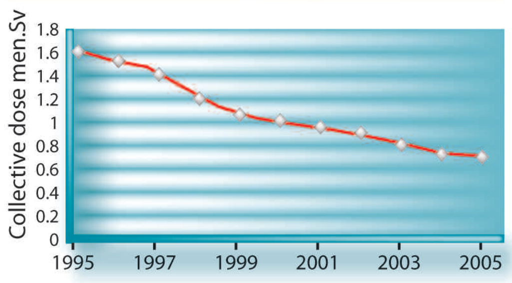
ASN assessment and actions taken

In 2005, the ASN checked that EDF had correctly taken account of the requests made further to the assessments and inspections carried out between 2002 and 2004 on the pressurised water reactors. The results of these actions and the corresponding conclusions are presented in section 6.1 of this chapter.

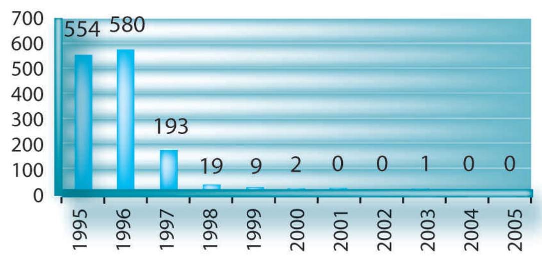
At the same time, the ASN has made changes to its supervision of worker radiation protection in nuclear power plants. The main efforts in this field chiefly concerned:
- more inspections on radiation protection and the associated tools;
- improved supervision of radiation protection during reactor outages;
- supervision of radiation protection at the EDF contractors;
- creation of a system for sharing experience among the various ASN entities concerning radiation protection issues in pressurised water reactors;
- analysis of radiation protection optimisation for the operations defined by the EDF head office.

An example of this last point is the analysis in 2005 of a particular operation which showed that application of the optimisation approach was satisfactory. However, the ASN asked that the dosimetric model used to estimate the doses prior to the work be improved, along with EDF's ability to put to good use the lessons learned from previous worksites.

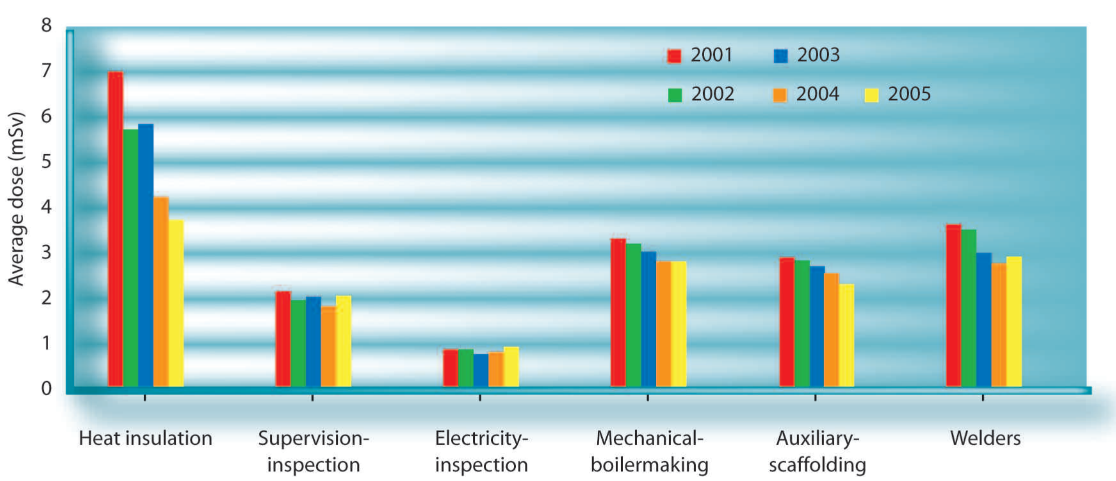
Mean collective dose per reactor (EDF data)



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)



Finally, the ASN initiated work in 2005 to compare radiation protection assessment methods in PWRs, through exchanges with the Spanish, American and Belgian nuclear regulators.

Particular points

The ASN supervised an experiment carried out by EDF and authorised in 2004, to inject zinc into the water of the primary system. This is part of an overall process to reduce collective dosimetry based on changes to the chemistry of the primary fluid in order to reduce the quantity of radioactive particles in the reactor systems.

Incidents

A specific analysis of significant radiation protection incidents declared is presented in point 5|1|2. A detailed analysis is given per origin and per subject.

4 | 2

Discharges from nuclear power plants

4 | 2 | 1

Discharge licence revision

Under application of decree n° 95-540 of 4 May 1995 concerning discharges of liquid and gaseous effluent and intake of water by BNIs, the ASN in 2005 continued to examine applications for renewal of the water intake and non-radioactive liquid effluent discharge licences for nuclear power plants. These licences, issued at prefectural level under the previous regulations in this respect, comprise a stipulated validity limit. At the request of the 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 examined were presented by EDF as soon as the previous licences reached their expiration dates. In particular, for sites where the authorisation deadline was imminent, the ASN fixed deadlines for the submission of licensee application dossiers by a decision of 4 July 2001. Thus, at the end of 2005, eleven 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 the 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, the 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 falling and are well below current limit values, so the ASN is reducing these limit values. For each of the 900 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 risen by a factor of 1.25 for liquid tritium discharges, assuming future high burnup fraction fuel management;
- with regard to non-radioactive substances, the ASN decided to improve on the previous discharge regulations.

4 | 2 | 2

Procedures carried out in 2005

Complete revision of the discharge and water intake licences

In 2005, examination of the effluent discharge and water intake licence renewal application for the Golfech plant continued. The public inquiry was held from 30 May to 13 July 2005.

A significant point is that since the application for the Cattenom NPP in 2004, EDF licence applications include an increase in liquid tritium discharge levels, linked to the future fuel management. In this respect, and for the plants concerned, EDF is submitting dossiers for France's consultation of the European Commission under the terms of article 37 of the Euratom treaty. For the Golfech plant, the European Commission's opinion dated 15 November 2005 was favourable, in particular in the light of the very slight radiological impact of the increase requested.

Examination has started on the discharge and water intake licence renewal applications for the Dampierre, Tricastin and Penly power plants.

Partial revisions

In 2005, the ASN concluded examination of the application for a liquid discharge licence as a result of monochloramine treatment to combat the growth of legionella in the secondary systems of the Chinon plant. Based on the results of a public inquiry from 25 April to 25 May 2005 and the data in the application dossier, the licence was granted on 17 August 2005.

In order to improve protection of the Belleville-sur-Loire nuclear power plant from Loire flood levels higher than the reference used in plant construction and to improve the safety of the plant's BNIs, EDF in 2004 submitted a licence application in accordance with the water law, concerning work to raise and extend the existing dyke. The licence was granted on 18 August 2005, after a public inquiry from 1 June to 2 July 2004.

Further to the formal notice delivered in 2003 by the 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 modified licence should be signed in early 2006.

In 2001, the ASN issued a formal notice to the licensee operating the Belleville-sur-Loire nuclear power plant following non-compliance with a number of requirements of the effluent discharge and water intake licence of 8 November 2000. The licensee then in 2002 submitted an application for modification of its effluent discharge licence. Given the absence of any assessment of the impact on NATURA 2000 sites in the application for modification of the discharge licence, the ASN considered that in 2004 the procedure could not be taken any further. In September 2005, the operator of the Belleville-sur-Loire plant submitted another application for modification of its effluent discharge and water intake licence of 8 November 2000, but this time it included an assessment of the impact on the NATURA 2000 sites. Examination of this application has begun.

Examination of management of associated radioactive and non-radioactive effluent

In 2004, the 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. 2005 was devoted to identifying and preparing the documents necessary for the examination. The opinion of the Advisory Committee is expected by the end of 2007.

4 | 2 | 3

Radioactive discharge values

Discharges in 2005

Every month the licensee communicates its discharge results to the 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 2005 results concerning radioactive effluent discharges are presented in the following graphs. The "Liquid radioactive discharge" graph presents the 2005 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 2005 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.

The gas discharge activity of the Nogent-sur-Seine nuclear power plant in 2005 is higher than the average with respect to two parameters. For the "halogens and aerosols" parameter, this is due to higher iodine releases than in the first quarter of 2005, mainly as a result of high iodine activity in the primary system resulting from loss of tightness of the fuel cladding and the presence of a leak in a system carrying primary coolant. For the "gas" parameter, this is due to higher releases of rare gases, mainly as a result of loss of tightness of the fuel cladding and the leak as mentioned above.

"Halogen and aerosol" gaseous discharges from the Golfech and Gravelines nuclear power plants in 2005 were also higher than the average for their respective plant series (1300 MWe and 900 MWe). This is explained by the higher releases of iodine, mainly due to the loss of tightness of the fuel cladding in reactor No. 1 at Golfech and reactor No. 6 at Gravelines.

The "halogens and aerosols" gaseous releases from Bugey are higher than the average for the 900 MWe plant series, owing to the higher iodine releases. The precise origin of these releases is currently being investigated.

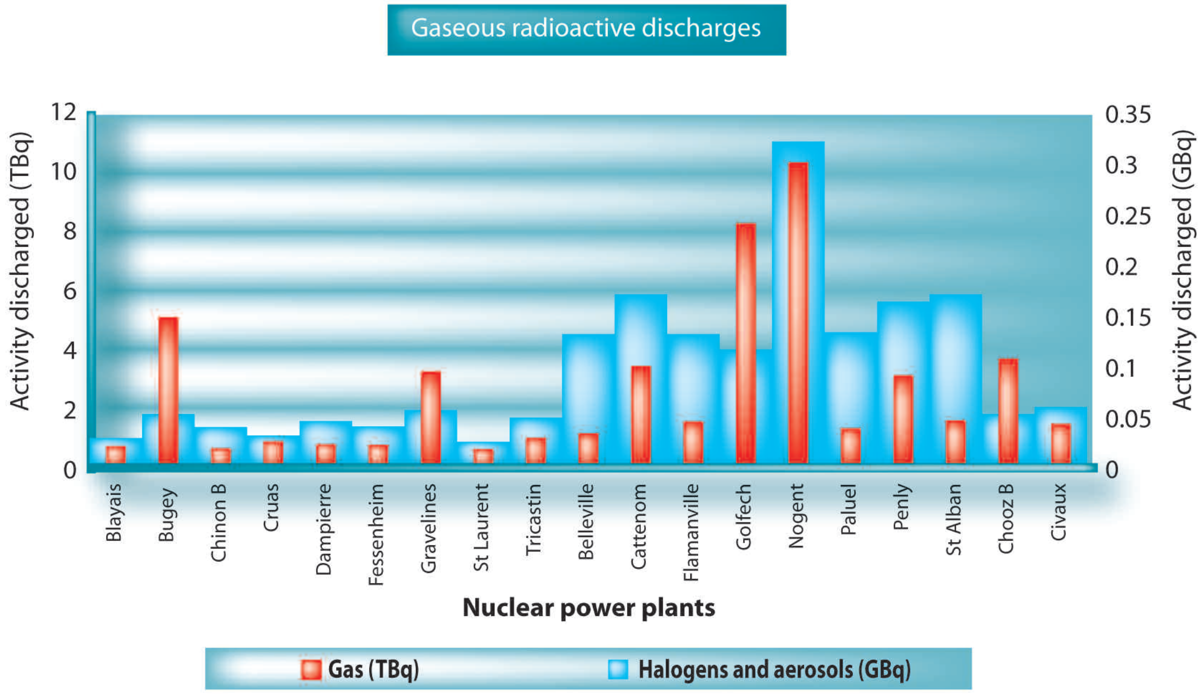
Radiological impact of discharges

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.

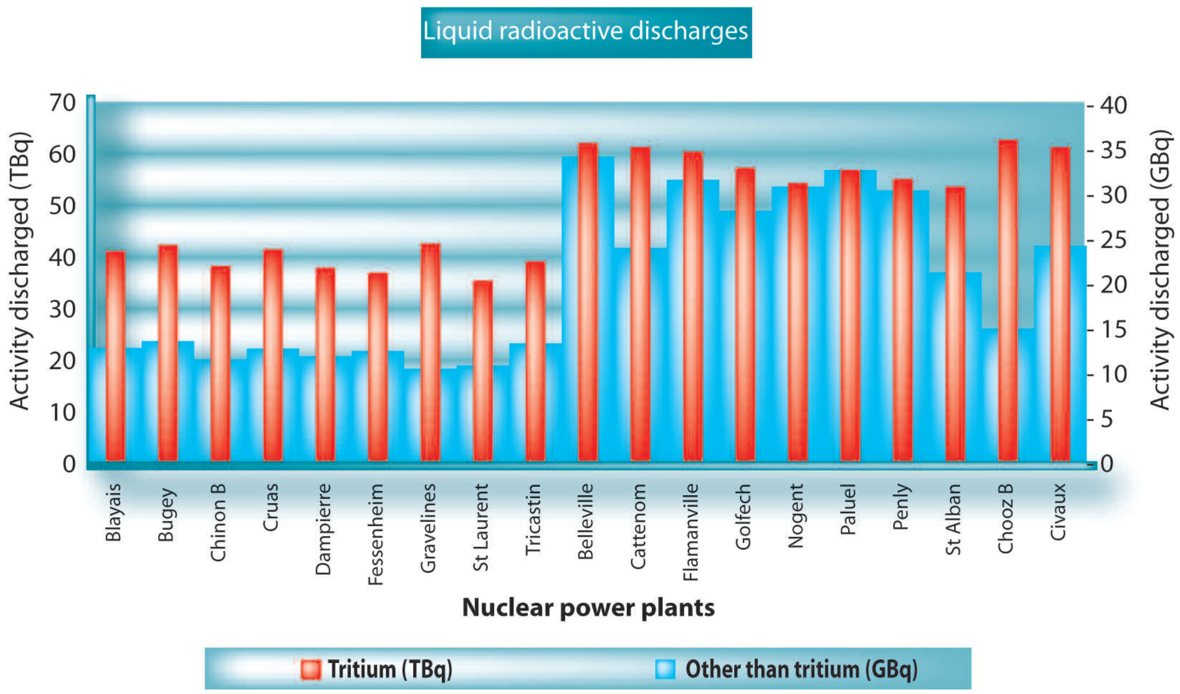
The annual effective dose received by the population reference group given in the EDF discharge and water intake licence applications is estimated at between a few microsieverts and a few tens of microsieverts per year.

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 2.3 microsieverts per year. As the actual discharges from the Nogent-sur-Seine nuclear power plant in 2005 were lower than the specified discharge limits, the actual annual effective dose in 2005 is less than this value.

Source: regulatory registers



Source: regulatory registers



4 | 3

Technological waste management

Following the ASN's decision of 10 November 2000 aiming to improve the conditions for interim storage of very low level (VLL) waste in nuclear power plants, all the plants commissioned VLL waste interim storage facilities.

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.

Observations in recent years tended to show that the safety of waste management in the BAN, BAC and BTE buildings was unsatisfactory, in particular with regard to containment, fire protection and radiation protection. At the end of 2002, EDF was asked to correct this situation.

The 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 inspections conducted by the ASN in 2005 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. The actual situation brought to light by these inspections 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). The lessons learned from these inspections will be reviewd by the ASN, in particular with regard to practices in this area, and will guide subsequent monitoring actions.

4 | 4

Protection against other risks and nuisances

4 | 4 | 1

The microbiological risk

Some of the energy produced by nuclear power plants is discharged into watercourses or into the sea via a cooling system.

The energy evacuated in the form of heat is discharged either directly into the environment or, for some nuclear power plants located along a river, after cooling in air cooling towers. This latter device is a means of evacuating some of the heat into the atmosphere, thereby reducing the thermal discharges into the rivers.

Owing to its chemical and biological properties, surface water can be propitious to fouling of systems and in particular lead to the formation of deposits and the growth of biofilms. These latter are an ideal medium for the development of micro-organisms such as amoebae and legionella in the cooling systems. Particular precautions must therefore be taken to prevent these micro-organisms from being dispersed into the environment.

The issue of the development of micro-organisms in the systems of power plants with cooling towers has been studied by EDF for a number of years now. It is the subject of periodic exchanges on the basis of EDF studies particularly with the Directorate General for Health (DGS) and the ASN, and is periodically reviewed during the sessions of the French high public health council (CSHPF).

Amoebae

The condenser is a heat exchanger which cools the secondary system with water taken from the river. The older versions of this equipment are made of brass, while the more recent models are made of stainless steel or titanium. Stainless steel and titanium were chosen in place of brass because they entail fewer metal releases through wear than brass, which generates releases of copper and zinc. The Bugey, Chooz, Dampierre (reactors 1 and 3), Golfech, Nogent-sur-Seine and Civaux plants are equipped with stainless steel or titanium condensers. The condensers at the Belleville, Cattenom, Chinon, Dampierre (reactors 2 and 4) and Saint-Laurent-des-Eaux (except reactor B1) plants are still made of brass, while those in Cruas and Saint-Laurent-des-Eaux (reactor B1) are half of them brass and half titanium.

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.

Conversely, owing to the development of amoebae in their cooling systems, and in order to meet 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 Bugey, Chooz, Dampierre (reactors 1 and 3), Golfech and Nogent-sur-Seine plants use monochloramine treatment, while the Civaux plant for its part uses UV treatment of the released cooling water owing to the Vienne river's greater sensitivity to chemical treatment discharges.

These measures allow effective compliance with the 100 Nf/l limit. Chemical substance discharges are for their part regulated by interministerial orders which limit the quantities of products released and require periodic forwarding of the measurement results to the ASN and to the health authorities.

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

Legionella

The legionella concentrations in the secondary systems cooling systems are variable and depend on a variety of factors (time of the year, use of anti-amoeba treatment, etc.). They can be significant, up to several hundred thousand colony forming units per litre (CFU/l), or even more than a million for those plants with no anti-amoeba treatment: Belleville, Cattenom, Civaux, Chinon, Dampierre (reactors 2 and 4) and Saint-Laurent-des-Eaux. They are less than a hundred thousand CFU/l on the other plants concerned: Bugey, Chooz, Dampierre (reactors 1 and 3), Golfech and Nogent-sur-Seine. The monochloramine treatment used against amoebae thus confirms its biocidal effect against legionella.

The ASN and the DGS considered that it was time to adopt a stance concerning the maximum concentrations for secondary system cooling systems in power plants equipped with cooling towers. In its letter of 28 January 2005, the ASN therefore asked EDF not to exceed certain legionella concentration levels in the secondary system cooling systems.

When setting these levels, account was taken of the results of EDF studies in which, for the same concentration in the systems, the large cooling towers (about 150 metres high) generate concentrations in the environment 50 times lower than the towers normally encountered in ICPEs (installations classified under environmental protection regulations). This value was reduced to 5 in the case of the Chinon nuclear power plant, where the cooling towers are of medium size (28 metres).

Thus the legionella concentration levels not to be exceeded in the secondary systems cooling systems are 5.10^6 CFU/l for nuclear power plants with large cooling towers, and 5.10^5 CFU/l for the Chinon nuclear power plant. The measurement frequencies are tailored to the measured concentrations. For systems other than the secondary system cooling system (air-conditioning for example), application of the legal current threshold for ICPEs is required.

As of the summer of 2004 and in order to avoid exceeding the level of 5.10^5 CFU/l, the licensee operating the Chinon nuclear power plant carried out chlorination of the water in the secondary systems cooling systems. Since the end of summer 2005, it has been operating a new monochloramine treatment unit, this time in order to treat legionella. On 17 August 2005, this installation was the subject of an order modifying the water intake and liquid and gaseous effluent discharge licence for operation of the Chinon nuclear site.

For the other plants without specific treatment, the value of 5.10^6 CFU/l is respected through the preventive servicing measures normally employed by EDF and designed to limit the development of biofilms.

To complement this stance, an expert appraisal of the situation appeared necessary, in particular to allow an assessment of the various studies, especially the health studies, conducted by EDF. The DGS, ASN and the Directorate for the Prevention of Pollution and Risks at the Ministry for the Environment, referred the matter to the French agency for environmental health safety.

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 more complete description of the provisions of this order is given in chapter 5, point 5|1.

For the particular case of the KER/TER/SEK effluent tank retention areas, the measures proposed by EDF in the files submitted by the deadline of 15 February 2002 were not considered to be acceptable by the ASN, which led EDF to propose new preventive measures. On the basis of the new provisions, considered to be equivalent to the requirements of article 14 of the order, the ASN decision of 17 August 2004 set a deadline of 15 February 2006 for conformity. EDF nonetheless stated that it could not meet this deadline and asked for authorisation to complete conformity of all nuclear power plants in mid-2007. This request is currently being reviewed by the ASN.

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 subjected 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 considers that noise linked to the presence of a weir or cooling towers is comparable to natural noise such as a waterfall.

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 consequently 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 those plants with cooling towers or a river weir, EDF proposed including their contribution in the residual noise.

The justifications provided by EDF are currently being reviewed by the ASN.

5 SUMMARIES

5 | 1

Summary of incidents

5 | 1 | 1

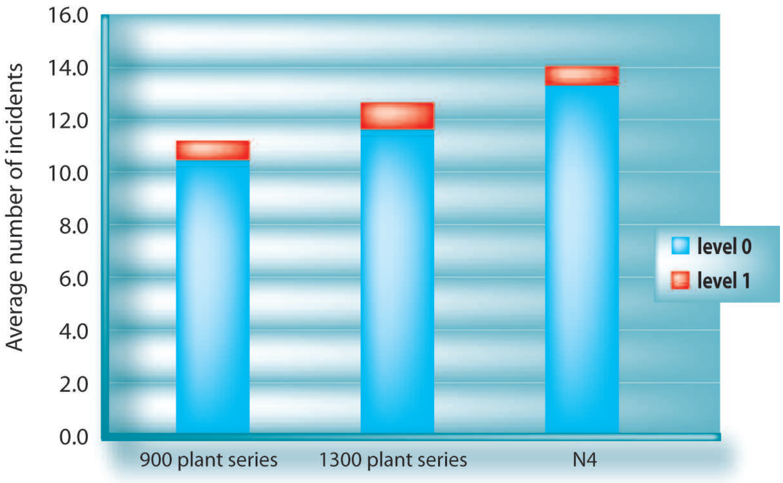
Summary of incidents in 2005

In application of the rules for declaration of safety, radiation protection and environmental incidents, EDF declared 759 significant incidents rated on the INES scale in 2005, 575 of which concerned safety, 170 of which concerned radiation protection and 14 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. 15 such events were declared in 2005.

The number of incidents declared in 2005 was higher than in 2004. This rise chiefly concerns the number of safety events declared and is in particular due to the rise in the number of incidents linked to application of technical operating specifications and quality assurance provisions. The proportion of incidents rated 1 on the INES scale is about 6.5%, or 47 incidents concerning safety, two

Average number of incidents per year and per EDF reactor for the year 2005



concerning radiation protection and none concerning the environment. The number of incidents classified 1 is down on 2004.

Furthermore, on 9 December 2005, the ASN rated as level 2 on the INES scale an anomaly concerning the water pumps on the low pressure safety injection system (RIS BP) and the containment spray system (EAS) for the EDF 900 MWe reactors (see point 2|2|1).

5 | 1 | 2

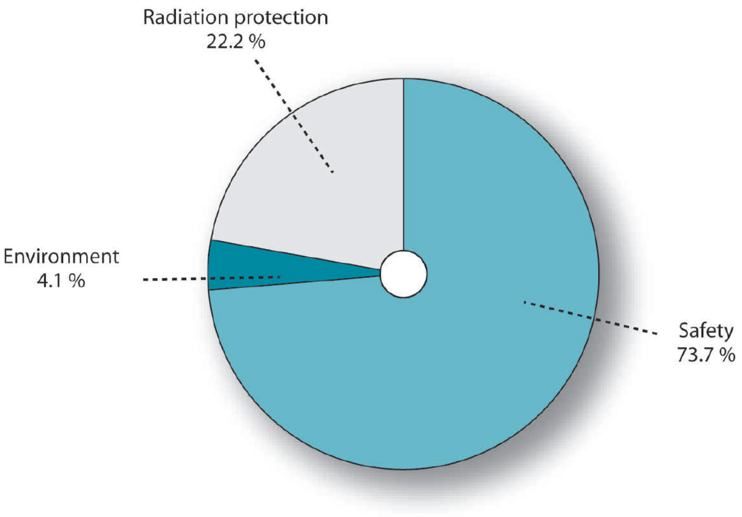
Statistical analysis of the incidents in 2005

The analysis is about the incidents declared between 1 December 2004 and 30 November 2005.

Breakdown of incidents on the EDF reactors in 2005 according to area of declaration

The areas concerned by the incidents declared by EDF are safety, radiation protection and the environment. The following graph presents the breakdown into these three areas of the incidents declared by EDF.

Breakdown of incidents per area



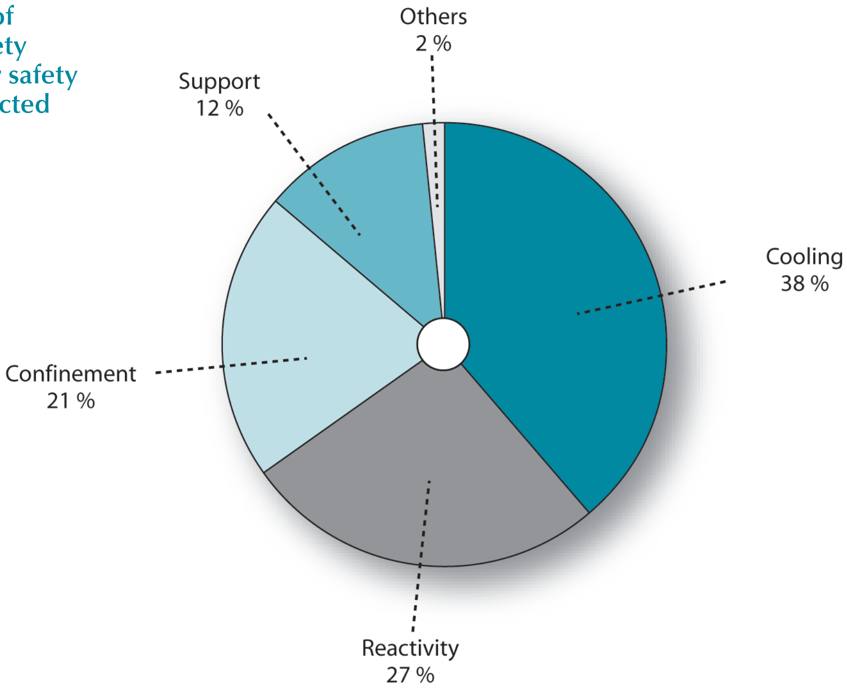
The number of radiation protection and environmental incidents declared remained stable from 2003 to 2004. In 2005, the ASN observed a drop in relation to 2004 in the number of environmental incidents declared and a rise in the number of safety-related incidents.

Breakdown of safety incidents which occurred in EDF reactors in 2005, per safety function affected and per reactor state

Safety is provided by three basic safety functions, that is reactivity control, cooling of radioactive materials and containment of radioactive materials. Certain incidents do not directly affect one of the three safety functions, but do affect auxiliary systems such as electrical power supplies. These incidents are represented under the "support" heading.

The following graph shows the breakdown of incidents per safety function affected during the event.

Breakdown of declared safety incidents per safety function affected



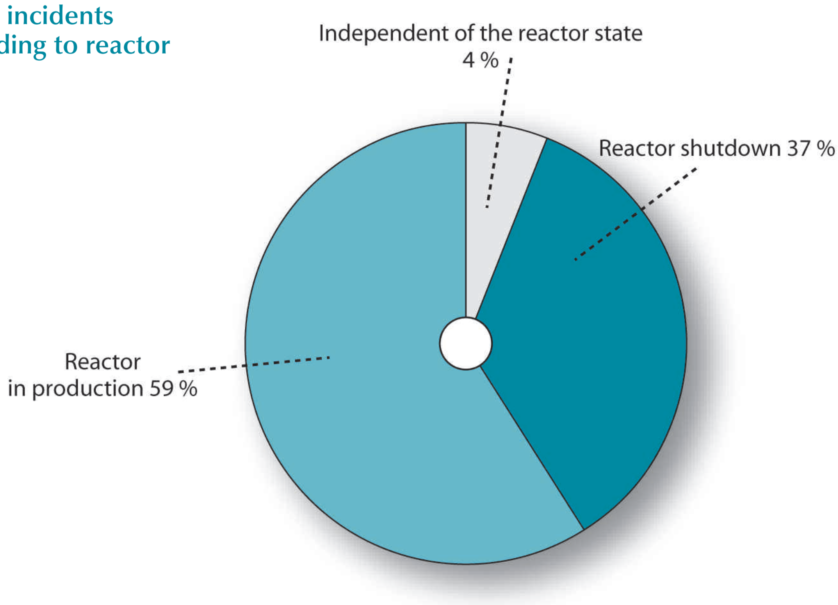
In 2005, the breakdown of incidents according to the safety function affected was appreciably the same as in previous years. The ASN did however observe a rise in the number of "support" function incidents, a trend which should be monitored and confirmed next year.

Safety incidents are also broken down according to the reactor state: some occurred while the reactor was in power operations, while others occurred during outages. The occurrence of certain incidents is independent of the reactor state and they are placed under the "Independent" heading.

The following graph shows this breakdown for EDF reactor incidents in 2005.

This graph shows that the number of safety incidents is higher when the reactor is in power operations than during an outage. The proportions remain similar to those obtained for 2004.

Breakdown of declared safety incidents according to reactor state

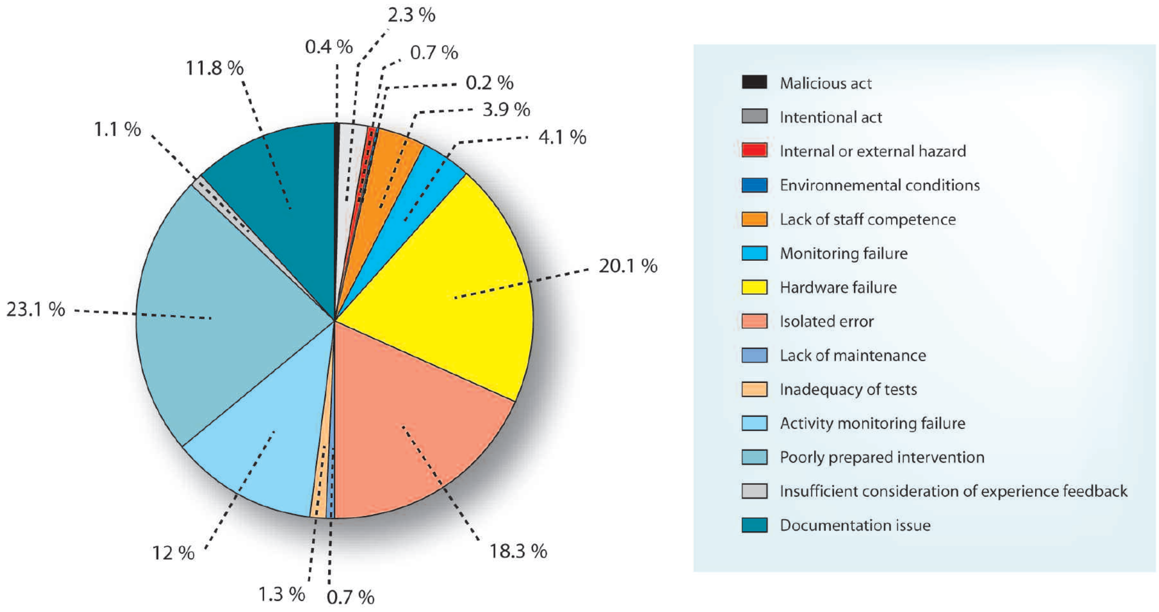


Breakdown of incidents on EDF reactors in 2005, according to the main cause

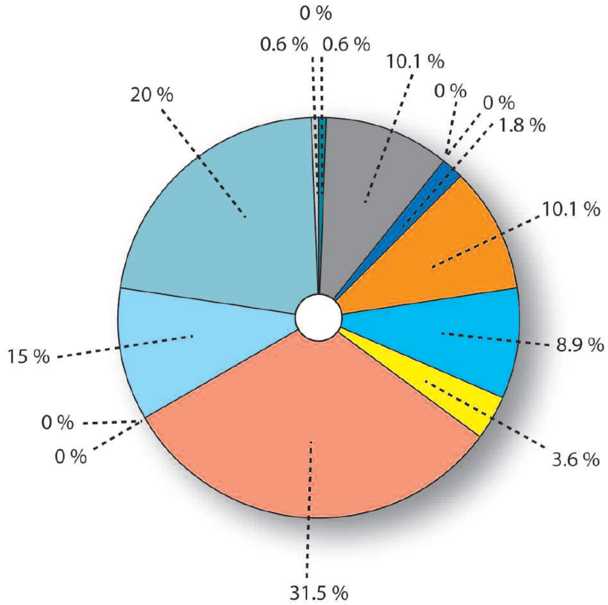
If we consider all the incidents which occurred on EDF reactors in 2005, independently of the area of declaration, the proportion of incidents linked to organisational and human causes is tending to rise, and went up from 75% in 2002 to 80% in 2005.

The graphs below show that the main causes of the incidents vary according to the area of declaration.

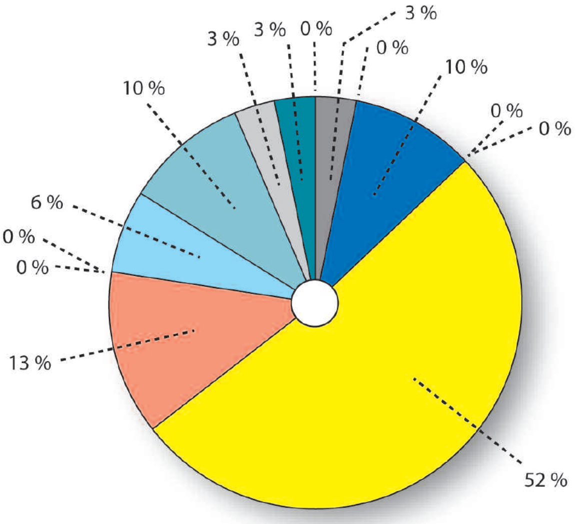
Breakdown of declared safety incidents according to main cause



Breakdown of declared radiation protection incidents according to main cause



Breakdown of declared environmental incidents according to main cause



The share of safety-related incidents declared is of the same order of magnitude as in previous years: nearly 20% of the incidents are linked to equipment faults and 80% to organisational and human causes. However, since 2003, a slight rise in the share of incidents linked to organisational and human causes is worth noting. This trend in particular concerns problems with preparation of maintenance (23%) and documentation problems (12%), which reflect a lack of stringency upstream of maintenance work that is important for safety, and problems with assuring and maintaining the quality of the documents required for preparing and carrying out these activities.

Among the organisational and human causes, it is also worth noting the following main origins: 18% are linked to isolated errors by the staff concerned and 12% to shortcomings in the supervision of operation and maintenance activities.

More than 95% of radiation protection incidents are linked to organisational and human causes. The following origins in particular should be noted:

- about 31% originate from specific errors, or 10% more than in 2004;
- 22% originate from incorrect preparation of the maintenance work, reflecting incomplete knowledge of radiological conditions at the maintenance location, failure to analyse interference between work sites or shifts in the schedule, the consequences of which were poorly identified;
- more than 20% originate in behavioural problems ("intentional act") or shortcomings in radiation protection ("lack of skills by one or more participants").

Environmental incidents are of three types, concerning:

- incidents linked to non-compliance with the requirements of the release orders (55%);
- release of ozone-depleting gases or greenhouse effect gases (13%);
- leaks or spillage of chemical or radioactive products (32%).

The proportion of incidents linked to releases of ozone-depleting or greenhouse gases is significantly down on 2004. EDF has made efforts to improve the situation regarding this type of release, a fact that could explain this trend if the reduction is confirmed in 2006. 70% of incidents concerning non-compliance with the requirements of the release orders have organisational and human causes, in particular specific errors on the part of the staff. With regard to the last two types of incidents, the origin is mainly due to equipment faults.

One must also underline the declaration of two incidents linked to malicious acts on two different sites. The first took place at Cattenom in December 2004 and concerned fire protection equipment, while the second occurred in April 2005 at Gravelines and concerned electrical equipment rooms. These two incidents had no safety, radiation protection or environmental consequences.

5 | 2

Significant events site by site

This table presents the most significant events over the year 2005 on each nuclear power plant. All incidents and generic anomalies can be consulted on the ASN web site (www.asn.gouv.fr) under the "Actualité" heading. Finally, additional information is obtainable from the DRIREs concerned.

BELLEVILLE

Site:

Administrative regularisation of the mechanical metalworking shop: technical requirements notified to the licensee by the ASN.

Signature of the order of 18 August 2005 authorising the site to modify the flood protection works.

BLAYAIS

Site:

Activation of an on-site emergency plan and triggering of the national emergency response organisation following a pressure rise in the reactor cooling system during an outage, leading to threshold overshoot on 27 October 2005.

Renewal of ISO 14001 certification.

Continued dredging of the Gironde river at the water intakes to prevent clogging by mud.

Real-time monitoring of thermal discharges into the Gironde, leading to adaptation of reactor power during the summer.

OSART mission in May 2005.

Reactor 4:

Performance of the second ten-yearly outage.

BUGEY

Site:

Submission of a file concerning construction of a processing centre for pathogenic waste from the cooling towers.

Reactor 3:

Outage for maintenance and refuelling with hydrotest on main secondary system.

CHINON

Site:

In-depth inspection from 7 to 11 March 2005 on the subject of fire, mobilising 9 inspectors for one week: this inspection in particular entailed a large-scale exercise involving activation of the on-site emergency plan and mobilisation of 23 vehicles from the departmental fire and emergency services.

Signature of the prefectoral order of 9 November 2005 authorising the site to build a temporary weir on the Loire river at Avoine and la Chapelle-sur-Loire, during severe low-water periods.

Approval for addition of equipment, construction and commissioning of monochloramine treatment installations on the secondary systems cooling systems.

Signature of the 17 August 2005 order modifying the 20 May 2003 order authorising water intake and discharge of liquid and gaseous effluent from the site.

Dredging of the intake channel.

Reactor 3:

Post-maintenance testing of the main secondary systems in application of the order of 10 November 1999.

CHOOZ

Reactor 1:

Incorporation of "end of series state" modifications package during the maintenance and refuelling outage which began in January 2005.

Replacement of a pole of the step-down transformer following a problem at unit restart. This work delayed reactor restart by one month.

CIVAUX

Site:

Post-maintenance testing of the main secondary systems on reactors 1 and 2.

First removal of spent fuel in November 2005.

Final start-up of reactors 1 and 2.

Reactor 1:

Strike by the operations team and a contractor for several weeks at the beginning of the reactor 1 outage.

CRUAS

Site:

Renewal of ISO 14001 certification.

Submission of a file requesting modification of the site's water intake and liquid and gaseous effluent discharge licence.

Repair of watertightness of radioactive liquid effluent storage tanks following detection of tritium in the site's underground water.

Reactor 1:

Performance of the second ten-yearly outage.

Reactor 4:

Unscheduled shutdown following rise in the leak rate between primary and secondary systems.

DAMPIERRE

Site:

Submission of a file requesting modification of the site's water intake and liquid and gaseous effluent discharge licence and beginning of review.

Performance of work to shore up the flood protection dyke.

Reactor 2:

Replacement of steam generators and post-maintenance testing in application of the order of 10 November 1999.

FESSENHEIM

Site:

National emergency exercise on 19 May 2005.

FLAMANVILLE

Site:

Steps taken to reduce the large amounts of nuclear waste in interim storage.

Geological surveys conducted in the summer of 2005 as part of the technical studies conducted with a view to installing an EPR reactor on the Flamanville site. These surveys were carried out on land and at sea using a drilling platform.

GOLFECH

Site:

National emergency exercise on 3 March 2005 with civil protection measures implemented by the prefecture.

Review of the site's water intake and radioactive and non-radioactive liquid and gaseous effluent discharge licence renewal application in progress.

Peer review from 16 May to 3 June 2005.

Reactor 1:

Replacement of the reactor vessel head during the maintenance and refuelling outage in summer 2005.

GRAVELINES

Site:

Beginning of work on the cofferdams to protect the heat sink. The cofferdam is a structure separating the intake channel from the discharge channel.

Reorganisation of radiation protection supervision to comply with the requirements of the radiation protection regulations.

Reactor 3:

Inadvertent triggering of the containment spray system during the maintenance and refuelling outage.

Reactor 4:

Replacement of the RIS and EAS systems sump filters.

Installation of hydrogen recombiners.

NOGENT

Site:

Application of the order of 29 December 2004 authorising water intake and liquid and gaseous effluent discharge.

Reactor 1:

INES Level 1 incident on 30 September 2005 with activation of the on-site emergency plan and triggering of the national emergency response organisation following accidental spraying of the electrical cabinets.

PALUEL

Site:

Massive arrival of algae at the pumping station, leading to automatic reactor trips.

Loss of off-site electrical power supply to the 4 reactors on 30 December 2005, owing to weather conditions.

Reactor 2:

Performance of the second ten-yearly outage from April to August 2005. This outage was the first of this type in France for the P4 plant series reactors. It led to significant maintenance work. The primary system and containment underwent hydrostatic testing.

PENLY

Reactor 1:

Replacement of the reactor vessel head during the outage in Spring 2005.

Reactor 2
The outage began one month early in August 2005 following discovery of significant damage to the condenser.

SAINT-ALBAN
Site:
Submission of an application for modification of the order authorising water intake and liquid and gaseous effluent discharge, in order to increase the discharge limits of several components and include the water intake channel dredging operations.
Reactor 2:
Complete inspection of the main secondary system during maintenance and refuelling outage.
Unscheduled outage following a generator stator protection fault. The outage, which began on 4 December, enabled the generator to be replaced and lasted 3 months.

SAINT-LAURENT-DES-EAUX
Site:
Inspection of 30 March 2005 carried out in the presence of the Chairman and an associative member of the CLI (local information committee).
National emergency exercise on 11 October 2005.
Reactor 1:
Second ten-yearly outage.
Reactor 2:
Performance of non-destructive tests following replacement of the steam generators in 2005.

TRISCASTIN
Site:
Submission of a file applying for renewal of the water intake and effluent discharge licence.
National emergency exercise on 24 November 2005 with evacuation of a part of the population.

6 ASSESSMENT AND OUTLOOK

6 | 1

ASN assessment of the past year

Reactor operations

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. However, in 2005, the ASN observed certain trends that will demand particular vigilance in 2006:
- quality problems in certain documents drafted by the EDF head office, and which the ASN had to ask EDF to correct;
- discrepancies in implementation by the sites of the national reference system, in particular with regard to documents concerning periodic tests;
- reference system interpretations which do not always benefit safety;
- existence of processes which lead to changes to the reference system without prior approval by the ASN.

On-site, the ASN observed discrepancies in application of the operating procedures, in supervision of activities and in preparation of maintenance work. A lack of stringency would seem to be the cause of these discrepancies and a factor in their persistence. However, the ASN did observe that through internal or external audits, the licensee had identified their weak points in this area and were extensively involved in steps to achieve progress, through “operational stringency” style action plans.

The ASN considers that the licensee is responsive to unexpected events, correctly manages operating incidents when they occur and learns the necessary lessons through a process of local and national experience feedback. The ASN believes that in addition to distributing incident experience feedback, distribution of good practices between the sites should be encouraged.

With regard to fire-fighting, efforts concerning organisation and equipment led to a reduction in response times, but staff backing for the organisation currently in place still needs to be improved.

The ASN notes with satisfaction the now generalised use of simulators for specific training to improve operating quality, through scenarios tailored to sensitive transients or resulting from an analysis of previous incidents. The ASN believes that joint training of the operating teams with the teams from other departments who are required to work in parallel with them is a practice to be promoted in order to improve communication and synergy between departments.

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 safety, radiation protection or operational issues. The ASN notes that so far, these changes have had no impact on safety.

However, even if the maintenance reference system is clear and of good quality, the site operators still have problems with keeping up with the rate of document updates required by head office. In 2005, the ASN also observed that the quality of maintenance preparation work was sometimes inadequate. The risk analyses in particular need to be conducted with greater stringency.

Most on-site maintenance activities are entrusted to subcontractors selected on the basis of an assessment and qualification system concerning which the ASN considered no particular comments to be necessary. The ASN observed that in 2004, the supervision of the activities entrusted to the subcontractors needed to be improved. It observed in 2005 that progress had been made on this point, through implementation of a national reference system designed to ensure that supervision was better organised and better implemented by the licensee. The situation does however need to be further improved for those aspects concerning the coordination of this improvement process and its correct implementation by all departments, the quality of the supervision programmes and the effective supervision of activities in the field. The ASN will in 2006 continue its monitoring and assessment of EDF on these points. During field inspections it will check that the action initiated continues, is better coordinated and takes account of acquired experience concerning supervisory methods and human resources.

The ASN considers that the skills and resources dedicated to maintenance are on the whole appropriate. The inspections carried out on the worksites however indicate that the workload imposed on the staff is heavy and that conventional workplace safety requirements are not always complied with.

Equipment condition

The ASN believes that the equipment maintenance and replacement programmes, the safety reviews approach and the questioning attitude consisting in checking the design and conformity of the facilities in order to correct any anomalies, help maintain the plant equipment in an adequate condition.

• First barrier

The 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.

• Second barrier

The ASN considers that the second barrier, mainly consisting of the primary system, remains satisfactory: EDF pays particular attention to it and implements stringent maintenance programmes. EDF action concerning the first generation of steam generators - replacement programme underway since the 1990s and targeted maintenance since 2004 - is helping to achieve significant improvements in their integrity. The ASN considers that it is necessary to maintain particular attention on controlling the ageing phenomena affecting the main primary system.

• 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 with the third ten-yearly outages in mind. EDF was asked for additional studies, particularly concerning containment in outage states, definition of third barrier extension and the “auxiliary buildings containment” doctrine.

The additional studies requested will be reviewed as of 2006. EDF also proceeded with its 1300 and 1450 MWe reactor containments tightness reinforcement work, scheduled to continue until 2011.

Radiation protection

The ASN observed that the active progress being made to improve radiation protection in the nuclear power plants is leading to a constant drop in individual and collective worker dosimetry. The national action plans defined and implemented by EDF to improve radiation protection are consistent with the diagnosis of the situation. The ASN in particular considers that reinforcing skills, working methods and supervision are appropriate actions.

Methodical implementation of these action plans has been initiated on the sites. Their effectiveness is being assessed and any necessary adjustments made. The ASN however observes that there are problems with having all the departments on the site follow the radiation protection approach and notes the lack of improvement in individual attitudes, which have been the cause of incidents.

Consequently, these action plans have not yet fully borne fruit and must be continued and possibly strengthened. For example, the staff “radiation protection culture” must be improved. Finally, progress is still needed in supervising application of radiation protection rules on the worksites.

The environment

The environmental protection regulations applicable to BNIs in general and to nuclear power plants in particular, have been gradually reinforced. In the field of discharges, the 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 order of 31 December 1999 introduces new requirements. The 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 installations design, EDF in 2005 continued its efforts to define and implement changes to improve the prevention of risks and detrimental effects. This work is satisfactorily coordinated by EDF head office.

Concerning discharges, the quality of the licence application files has improved, but changes are still needed before the files can be considered acceptable. The ASN notes that in 2005, the requirements of the discharge licence orders were on the whole followed. It should be stressed that given the fact that the new authorised discharge limits are set as close as possible to the actual discharges, in order to urge the licensee to reduce its discharges to a level as low as reasonably achievable, any underestimation in the application dossier of the quantities discharged is likely to lead to non-compliance with the licence.

In the field of waste, and at the request of the ASN, EDF conducted safety analyses of waste management activities. The main conclusion from examination of these documents is the absence of any precise operating reference system. In 2005, the ASN also found that despite increased licensee awareness of the need for improvements to their waste management procedures, a lack of equipment availability led to significant congestion of the waste disposal and packaging buildings on certain sites.

Personnel and organisation

The ASN considers that EDF's organisation is on the whole capable of dealing with safety questions. The fact that safety is the main priority is plainly apparent. The ASN recognises the competence and professionalism of the EDF staff. Managers are increasingly present in the field and the manning levels are generally speaking appropriate, although there are still some inadequacies in the maintenance area, particularly during unit outages and with sometimes problematical maintenance conditions. As a whole, EDF must improve how organisational and human factors aspects are incorporated into field activities, in particular in the maintenance sector.

Action plans have been implemented to improve maintenance and operating stringency, but the ASN considers that further progress is still needed, particularly in terms of internal supervision and thoroughness in application of the reference documents. More generally, individual and collective attitudes must give greater importance to the safety culture.

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Outlook

For EDF's nuclear power plants, 2005 was marked by important events which will help determine supervisory actions for 2006.

First of all, the launch of the national public debate concerning the "Flamanville 3" EPR reactor project, after which EDF would be able to submit a creation decree application. Prior to any submission of such an application, the ASN will in 2006 continue to review the detailed design studies for the EPR reactor, with reference to the safety options stance adopted by the Government in 2004. It will also continue to cooperate with foreign nuclear safety authorities, in particular the Finnish one, in order to include international viewpoints in its safety assessment.

Reports on safety harmonisation drafted by WENRA, particularly for power reactors, will also be published. The heads of the nuclear safety authorities from Europe's leading nuclear countries have agreed, on this basis, to achieve a harmonised safety situation by 2010. In 2006, the ASN will continue to transcribe into France's regulatory or related texts, the "reference levels" produced by WENRA. The ASN considers this work to be a priority, as harmonisation of safety standards in Europe is one means of continuing to take safety forward in an environment marked by deregulation of the electricity markets and an increased focus on competitiveness (see chapter 7 and the significant events in 2005).

A final issue will be the partial sell-off of EDF in November 2005, after the change in status in 2005, and the opening up of the electricity market to competition, a move which started in 2000. EDF has initiated numerous cost reduction and competitiveness improvement programmes, which are submitted to the ASN supervision whenever they affect safety issues. Even if the ASN reckons that it is perfectly normal for a company to be concerned by its competitiveness, it nonetheless keeps a very close watch on the safety consequences of this search for improved competitiveness. At this stage, no negative effects have been recorded but the ASN is remaining vigilant as to how the licensee reflects its search for profitability in its long-term investment choices and as to the day to day actions of its staff.

The ASN in particular considers that the condition of the facilities is satisfactory and that EDF applies appropriate operating methods - maintenance programmes and operating rules - taking due account of the lessons to be learned from experience feedback. In the fields of radiation protection and environmental protection, the ASN notes that EDF has adapted to a context of stronger regulation and considers that in 2005, EDF’s results have on the whole progressed. Supervision of activities entrusted to subcontractors, a point to which ASN had drawn EDF’s attention at the end of 2004, is improving. However, the ASN expects still greater progress in the stringency of operation and maintenance, and in worksite operating conditions.

The particularity of France is that it operates standardised NPPs which meet nearly 80% of the national electricity demand. Although this situation leads to extremely efficient experience feedback between the reactors, it does demand that a particularly close watch be kept on the possible appearance of generic defects. The conformity reviews, the permanent search for anomalies by the EDF engineering departments, the tests and inspections carried out during the ten-yearly outages are all opportunities for obtaining good knowledge of the current level of safety of the facilities. The ASN observes that this positive approach continued in 2005, and led to conformity being restored within times compatible with safety significance. The work designed to prevent the risk of reactor building sump clogging was thus started and the ASN will monitor its continuation in 2006.

It is also important for EDF to continue to take steps to improve safety still further. Integration of the changes resulting from the 900 MWe reactors second periodic safety review continued in 2005 and will be completed in 2010. Furthermore, the second ten-yearly outages on the 1,300 MWe reactors began in the spring and will continue until 2014. 2005 was also marked by review of the programme associated with the periodic safety review of the 900 MWe reactors with a view to their third ten-yearly outages, scheduled to run from 2009 to 2020.

Finally, with regard to power reactor supervision procedures, the ASN carried out inspections to verify the correct working of the “internal authorisations” system set up in 2005. This system enables EDF to carry out operations which do not compromise the safety demonstration, without first having to ask the ASN for authorisation. This system, which at present only covers a very limited scope, could be extended in 2006. This would shift the burden of responsibility more squarely onto EDF, thereby correcting a natural tendency to leave it up to the ASN to check the quality of the files, a task which should be the prime responsibility of the licensee. This also enables the ASN to concentrate its supervisory actions on those subjects with more important safety issues.

In his letter of 20 September 2006, which can be found on the www.asn.gouv.fr website, the Director General of the ASN drew the attention of EDF’s Chairman to these various points.