EDF NUCLEAR POWER PLANTS

CHAPTER 12

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 NPPs described in the other chapters of this report produce the fuel intended for these plants or reprocess it, are used for disposal of the waste produced by them or are used to study 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.

1 GENERAL INFORMATION ABOUT EDF'S NPPs

The nineteen French nuclear power plants (NPPs) currently in operation are appreciably the same. They each comprise from two to six PWRs, which in total amounts 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 reactors, consisting of the four reactors at Bugey (reactors 2 to 5) and two reactors at Fessenheim;
- the CPY reactors, consisting of another twenty-eight 900 MWe reactors, that can also be subdivided into CP1 (eighteen reactors at Blayais, Dampierre-en-Burly, Gravelines and Tricastin) and CP2 (ten reactors at Chinon, Cruas-Meysse and Saint-Laurent-des-Eaux).

The twenty 1300 MWe reactors comprise:
- the P4 reactors, consisting of the eight reactors at Flamanville, Paluel and Saint-Alban ;
- the P'4 reactors, consisting of the twelve reactors at Belleville-sur-Loire, Cattenom, Golfech, Nogent-sur-Seine and Penly.

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

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

Power reactor locations in France

The CPY reactors differ 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 the CPY reactors. The power increase means a primary system with four steam generators (SG), 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 as with the 900 MWe reactors.

The P'4 reactors differ slightly from the P4 reactors, notably with regard to the fuel building and primary and secondary systems.

Finally, the N4 reactors differ from the previous reactors in the design of the more compact steam generators and of the primary pumps and in the computerisation of the control systems.

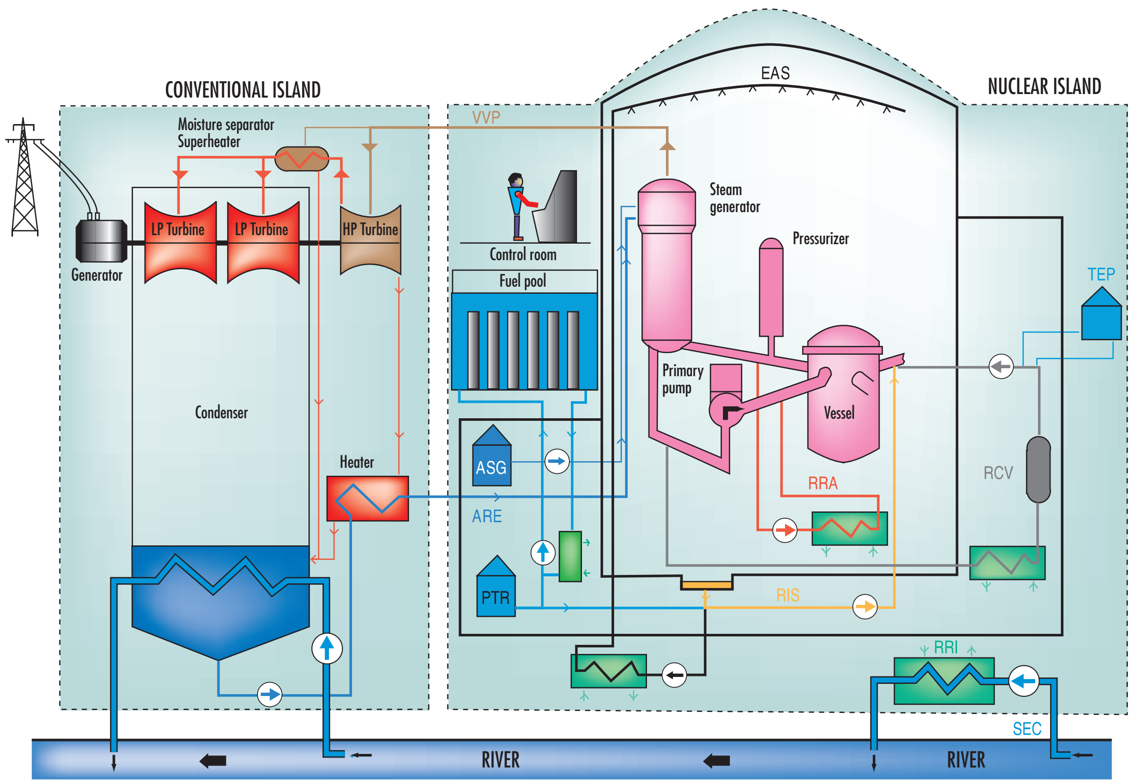
1 | 1 Description of an NPP

1 | 1 | 1 General description of a pressurised water reactor

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

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

The nuclear island mainly consists of the nuclear steam supply system comprising the primary system and the

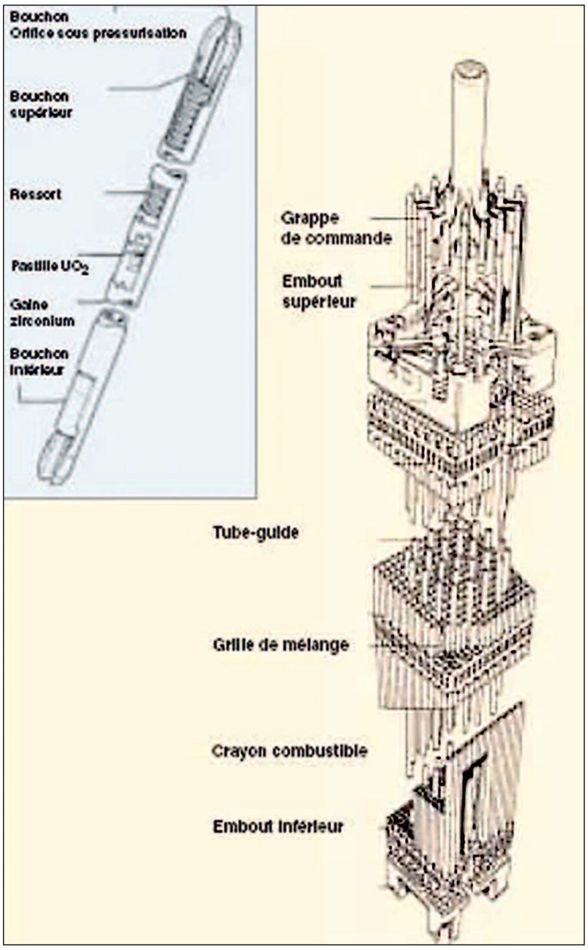


Block diagram of a pressurised water reactor systems designed for reactor operation and safety: the chemical and volume control, residual heat removal, safety injection, containment spraying, steam generators feedwater, electrical, C&I and reactor protection systems. Various support function systems 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 fuel storage pit.

The conventional island equipment includes 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.

The safety of pressurised water reactors is guaranteed by a series of strong, independent, leaktight barriers, for which the safety case must demonstrate their effectiveness in normal and accident operating situations. There are generally three of these barriers, consisting of the fuel cladding (see point 1|1|2) for the first barrier, the main primary and secondary systems (see point 1|1|3) for the second barrier and the reactor containment building (see point 1|1|4) for the third barrier.



Fuel rod for a pressurised water reactor – Fuel assembly and rod cluster control assembly

1|1|2 Core, fuel and fuel management

The reactor core consists of rods containing uranium oxide pellets or mixed uranium and plutonium oxides (MOX fuel), located in fuel assemblies, contained in a steel vessel. As a result of fission, the uranium or plutonium 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 system 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:
– inserting control rod assembly clusters, containing elements that absorb neutrons, to varying depths in the core. 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 content of the primary system water. The chain reaction is moderated by the boron – in the form of boric acid dissolved in the primary system water – owing to boron's ability to absorb neutrons. 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 reaches zero. An extension is however possible, if the temperature and possibly the power level are brought below their nominal values. At the end of the campaign, the reactor core is unloaded for renewal of part of the fuel.

EDF uses two types of fuels in its pressurised water reactors:
– uranium oxide (UO_2) fuel enriched with U-235. Most of this fuel is manufactured by FBFC, a subsidiary of the AREVA group. However, with a view to diversifying its supplies EDF has, since 1980, been obtaining fuel from several foreign fuel manufacturers. The level of uranium 235 enrichment of the UO_2 fuel loaded into the reactor is limited to 4.2%;

– fuels consisting of a mixture of depleted uranium oxides and plutonium (MOX). MOX fuel is produced by the MELOX plant that belongs to the Areva group and is located at Marcoule (Gard *département*[1]). The initial plutonium content is limited to an average of 8.65% per fuel assembly and provides an energy equivalence with UO_2 fuel initially enriched to 3.7% Uranium 235. This fuel can be used in the CP1 and CP2 reactors for which the authorisation decrees (DAC) make provision for MOX fuelling. Twenty-two of the twenty-eight reactors are concerned.

Fuel management is specific to each 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 an operating cycle (generally expressed in months);
– the number of new fuel assemblies loaded at each reactor refuelling outage (generally 1/3 or 1/4 of the total number of assemblies);
– the reactor operating mode, with or without major power variation, characterising the stresses to which the fuel is subjected.

1 | 1 | 3 Primary and secondary systems

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

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

The primary system water transfers the heat to the water in the secondary systems, via the steam generators.

The steam generators contain thousands of tubes through which the primary water circulates. These tubes are immersed in the water of the secondary system and boil it. This water never comes into contact with the primary water.

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 reheaters.

1 | 1 | 4 Reactor containment building

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

The containments are of two types:
– the 900 MWe reactor containments, consisting of a single wall of pre-stressed concrete (concrete containing steel cables tensioned to ensure compression of the structure). This wall provides mechanical resistance to the most severe design accident pressure and structural integrity against external hazards. Leaktightness is assured by a thin metal liner on the inside of the concrete wall;
– the 1,300 MWe and 1,450 MWe reactor containments, comprising two walls, an inner wall made of prestressed 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, channels any radioactive fluids and fission products that could come from inside the containment as a result of an accident. Resistance to external hazards is mainly provided by the outer wall.

1 | 1 | 5 The main auxiliary and safeguard systems

In normal operation or during normal shutdown of the reactor, the role of the auxiliary systems is to provide the basic safety functions (control of neutron reactivity, removal of heat from the primary system and fuel residual heat,

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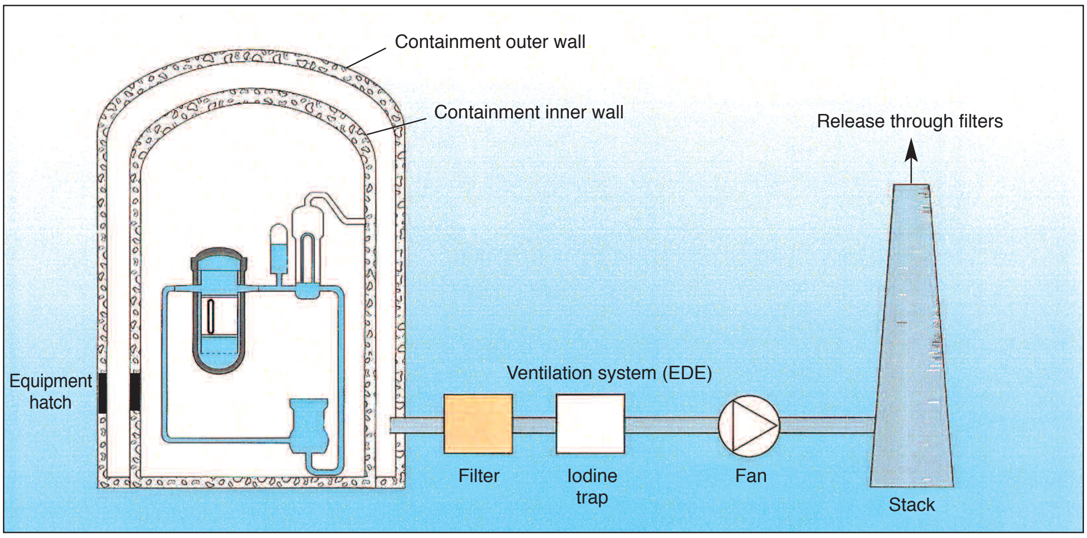


Containment of a 1300 MWe reactor

containment of radioactive materials). This chiefly involves the Chemical and Volume Control system (RCV) and the Residual Heat Removal system (RRA).

During operation, the RCV system can be used to control neutron reactivity by regulating the boron concentration of the primary coolant water. It is also used to adjust the mass of water in the primary system according to temperature variations. The RCV system also enables the quality of the primary system water to be maintained, reducing the amount of corrosion and fission products it contains by injecting chemicals (corrosion inhibitors for instance). Finally, this system permanently injects water into the primary pump seals to guarantee their tightness.

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

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 moderate the nuclear reaction and remove the residual heat. It comprises passive pressurised accumulators and various pumps with appropriate discharge flow rates and pressures for different types of accident situations. In the event of a loss of coolant or steam line rupture accident, these pumps initially draw from the reactor cavity and spent fuel pit cooling and treatment system tank (PTR). Then, when the tank is empty, these pumps 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 rise in the pressure and temperature in the reactor building, the EAS system sprays water containing soda. This helps restore acceptable ambient conditions, protect the integrity of the containment and damp down any radioactive aerosols dispersed inside the containment.

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

1 | 1 | 6 Other systems

The systems necessary for reactor operation and important to its safety also include:

– the component cooling system (RRI), which cools a number of nuclear equipment items; this system operates in a closed loop between the auxiliary and safeguard systems on the one hand, and the systems carrying water pumped from the river or the sea (heat sink) on the other;

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

1 | 2 Operation of an NPP

1 | 2 | 1 EDF's organisational structures

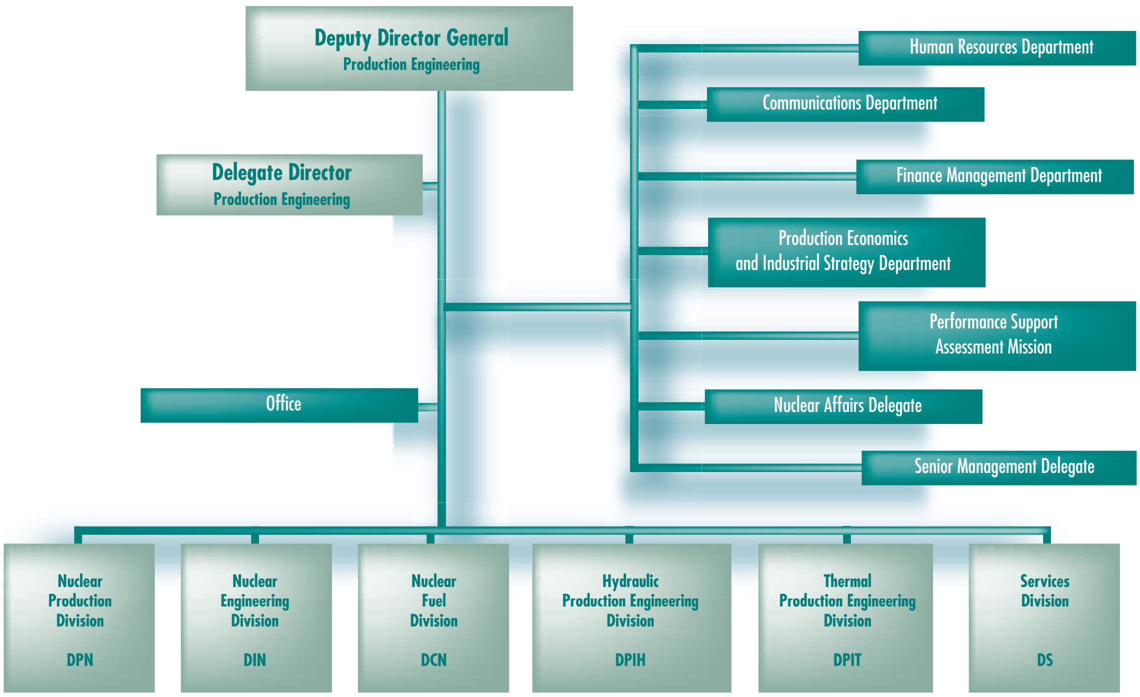
Within the EDF Production and Engineering Directorate (DPI), a distinction is made between the functions of operator and designer. The designer is responsible for developing and extracting long-term value from EDF's assets, along with dismantling at the end of operation. The operator is responsible for the short and medium-term performance of its production sites, as well as for safety, radiation protection, security, environmental, availability and daily operating costs issues.

The DPN

The responsibility of operator is assumed by the Nuclear Operation Division (DPN). Day-to-day operation of the NPPs, including safety, worker radiation protection and security, along with availability and costs, are its duties. The Director of the DPN has authority over the NPP 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 operations.

The role of the Operation Engineering Unit (UNIE) is to support NPPs and DPN management. It is responsible for policy and requirements concerning safety, radiation protection and environmental protection. UNIE therefore drafts the safety requirements applicable to the NPPs and ensures that they are implemented. It helps NPPs achieve their safety and performance objectives. It helps the DPN management in the performance of its duty to manage and control implementation of national decisions concerning all NPPs. The UNIE also helps support the DPN management and the NPPs in implementing changes and integrating technical aspects and human, social, organisational and economic factors.

For all power plants, the Central Technical Department (UTO) is responsible for implementation of operations



Organisation of the EDF Production Engineering Department (DPI) (modifications and maintenance). It is in charge of generic maintenance, subcontracting policy, oversight of reactor outages and purchasing policy.

Finally, the IN (Nuclear Inspection) teams, on behalf of the DPN authorities, carry out verification assignments on the entire division.

Within the NPPs, the Director's responsibilities are those of the nuclear licensee of the NPPs. The departments are organised according to discipline, comprising safety, radiation protection, production and maintenance. Cross-functional project teams are set up for specific activities such as unit outages. The production and maintenance activities can also call on an engineering department.

The DIN

The role of designer is assigned to the Nuclear Engineering Division (DIN). In this respect, the DIN is responsible for the NPPs' design requirements. It performs engineering activities concerning future issues, in other words, studies, draft projects and long-term upgrade projects for the NPPs which go beyond the natural scope of the licensee's work. Finally, it oversees projects designed to maintain the assets, primarily design aspects and in particular the periodic safety reviews. It is responsible for new NPP projects in France (EPR Flamanville 3) and those taking place abroad in which EDF is involved. It is responsible for dismantling work.

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 in charge of equipment design and modification on the nuclear island of the N4 reactors and the new NPP projects in France (EPR FA3) and abroad.

The Nuclear Equipment Engineering Department (CIPN) is in charge of the nuclear islands for the 900 MWe and 1300 MWe reactors.

The National Electricity Generating Equipment Centre (CNEPE) deals with the conventional islands of all the plants.

The dismantling and waste management activities are handled by the Nuclear Environmental and Decommissioning Engineering Centre (CIDEN).

Finally, the Construction and Operation Expert Appraisal and Inspection Centre (CEIDRE) is responsible for in-service inspection of equipment and for conducting appraisals.

ASN contacts

As part of its national regulatory role, ASN maintains relations mainly with the DPN concerning the power plants in operation and the DIN for new projects. ASN's contacts are the DPN head office departments with regard to handling of generic matters, that is those concerning several if not all of the reactors in service. ASN deals directly with the management of each power plant for issues specifically concerning the safety of the reactors in it. 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 Fuels Division (DCN).

1 | 2 | 2 Operating documents

NPPs are operated on a day-to-day basis in accordance with a set of documents. All those concerning safety are given particularly close attention by ASN.

These first of all comprise the general operating rules (GORs) applicable to reactors in service. They supplement the safety case, which mainly deals with the measures taken at the design phase of the reactor, and translate the initial scenarios and findings of the various studies into operating rules.

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

• Chapter III describes the Technical Operating Specifications (STEs), which specify the reactor's normal operating range and in particular the allowable range for the operating parameters (pressure, temperature, neutron flux, chemical and radiochemical parameters, etc.). The STEs also specify the required reaction if these limits are exceeded. In addition, the STEs define the equipment needed according to the condition of the reactor and state what action is to be taken in the event of malfunctioning or unavailability of this equipment.

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

• Chapter IX defines the programmes of checks and periodic tests run on the equipment and systems that are important for safety, in order to ensure their availability. If the results are unsatisfactory, then the required response is specified in the STEs. This type of situation may sometimes require the licensee to shut down the reactor in order to repair the faulty equipment.

• Chapter X finally defines the physical test programme for reactor core loads. It contains the rules defining the core verification programmes during reactor restart and for in-service core monitoring.

Secondly, there are documents describing the in-service monitoring and maintenance actions required on the equipment. On the basis of the manufacturer recommendations, EDF defined periodic inspection programmes for the components, or preventive maintenance programmes (see point 3|2|1), based on the knowledge of the potential failures of the equipment.

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

1 | 2 | 3 Reactor outages

Reactors need to be shut down periodically in order to renew the fuel, which becomes gradually depleted during the operating cycle. At each outage, one third or one quarter of the fuel assemblies is replaced. The length of the operating cycles depends on the fuel management adopted.

These outages mean that it is possible to access parts of the NPP which would not normally be accessible during operation. The outages are therefore an opportunity to check the condition of the NPP by running checks and performing maintenance work, as well as to implement the modifications scheduled for the NPP.

There are two types of outage:
– simple refuelling outage and partial inspection (VP) outage: these outages last a few weeks and are devoted to renewing part of the fuel and conducting a programme of verification and maintenance;
– ten-yearly outage (VD): 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 safety reviews (see point 2|2|3).

These outages are scheduled and prepared for by the licensee several months in advance. ASN checks the steps taken to guarantee safety and radiation protection during the outage, and the safety of operation during the coming cycle(s).

The checks carried out by ASN mainly concern the following aspects:
– during the outage preparation phase, conformity with the applicable reactor outage safety requirements. ASN adopts a stance on this aspect;
– at the regular information meetings and inspections during the outage, how the various problems encountered are dealt with;
– 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, ASN authorises reactor restart;
– after criticality, the results of all tests carried out during the outage and after restart.

Piping check by an ASN inspector during the primary system hydrotest (Cattenom in the Moselle *département*) – June 2008

2 THE MAJOR NUCLEAR SAFETY AND RADIATION PROTECTION ISSUES

2|1 People, organisations, safety and competitiveness

A BNI is a socio-technical system, in other words, a system in which the social and technical characteristics are closely interconnected. Safe operation of the NPP does not depend only on the technical components of the system, nor does it rely solely on the people and organisations making up the social components of the system. It is to a large extent dependent on the quality of the combination of the two components (technical and social) of the socio-technical system.

The contribution of man and organisations to managing BNI safety is thus a determining factor in the NPPs in operation, but also in their design, construction and decommissioning. Ensuring that this contribution works constantly to improve safety is all the more important given that safety is always faced with other considerations, such as competitiveness.

ASN is of the opinion that licensee consideration of human and organisational factors (HOF) is a key component in NPP safety. ASN reviews how the licensee takes account of these factors in the safety of the NPP. This review is described in point 2|1|1.

The contribution made by individuals and organisations is partly based on their competence. ASN checks that measures are taken by the licensee to ensure that adequate and appropriate resources are available and are allocated to the tasks for which their competence is required. A review of these measures is presented in point 2|1|2.

EDF's nuclear safety policy, and the management system put into place to maintain and improve the safety of its NPPs, have an impact on how individuals and organisations contribute to safety management. The ASN review of the safety management arrangements is presented in point 2|1|3.

Of the day to day activities carried out by the parties concerned, some are entrusted to contractors or subcontractors. The ASN review of the steps taken by EDF to ensure that with regard to these activities, the contributions by individuals and organisations are taken into account and work towards improving safety, is presented in point 2|1|4.

2|1|1 Regulation of human and organisational factors

For ASN, HOF can be defined as concerning all elements of a working situation and organisation which have an influence on the actual activity of the players in the socio-technical system that is an NPP. These elements in particular concern everything relating to the organisation of work, manpower and skills, technical and working environment arrangements, that is all those elements which, at an individual, collective or organisational level, contribute directly or more indirectly to the performance of activities such as to enable the socio-technical system to carry out its roles safely.

The approach taking account of HOF in the operation or modification of existing NPPs, or the design and construction of future NPPs, concerns all these elements so that HOF-related lines of defence cover the entire scope of the socio-technical system.

Therefore, training designed to improve the skills of the operators will only have an isolated and limited effect on the socio-technical system if elsewhere there are inadequacies in the technical arrangements, such as inappropriate tools, inadequate marking of equipment or man-machine interface information that does not match the needs of the reactor control operators. The same would apply to shortcomings in the working environment, such as inappropriate ambient lighting or noise, or in the organisation of work whereby, for example, the distribution of roles and responsibilities is poorly defined or poorly understood by the operators.

In a preventive approach, as well as in response to the occurrence of deviations or events, the appropriateness of the improvement actions depends on the quality of the deviation cause analyses and more broadly on all elements which, in the working situation, can be the cause of difficulties and lead to inappropriate actions on the part of those involved. Without an analysis and detailed diagnosis of the situation before drawing up an action plan, the improvement actions may have no effect in the field, fail to produce the expected effects, or even prove counterproductive.

This analysis approach is based on methods that are recognised in the field of human sciences, adapted to offer the best possible guarantee that the improvement actions do indeed cover the scope of the causes, in particular human causes, behind the potential or confirmed deviations, and that these actions are actually implemented.

ASN regulation

ASN considers that the licensee must take account of HOF not only through isolated actions such as training or a workstation ergonomic study, but also through an HOF approach which is:

– integrated into the safety management system;

– backed by a commitment on the part of the NPP's management to take account of HOF in a way commensurate with the safety and radiation protection issues;
– robust and part of a long-term view of risk management, with a view to continuous improvement;
– systemic and which considers the entire socio-technical system: it does not look simply at human error, in other words inappropriate actions by the front-line operators;
– focused on assessing and strengthening the lines of defence linked to human activities;
– given appropriate, long-term means of action, in particular personnel resources qualified to deal with HOF;
– based on an analysis of working situations and worker activities;
– participative, involving all parties concerned, regardless of their hierarchical level.

ASN therefore expects the licensee to define an explicit policy to take account of and develop HOF, to acquire the appropriate means and resources for effective action and take steps according to appropriate approaches and methodologies, that are managed and followed-up with a view to continuous improvement.

ASN regulation of HOF is based in particular on the inspections performed in the NPPs. These inspections are an opportunity to review the licensee's HOF policy and organisation, the means and resources committed, particularly in terms of specific skills, the steps taken to improve how HOF are incorporated into operations and to assess actual implementation and results in the field. ASN also relies on the assessments carried out at its request by IRSN and the Advisory Committee for nuclear reactors (GPR).

Incorporating HOF into engineering activities

ASN considers that the licensee must systematically adopt a human and organisational factors engineering approach when designing a new NPP or modifying an existing one.

An approach such as this is a means of ensuring that all HOF are taken into account from the outset of the design stage, so that the individuals and working teams can, after commissioning, operate the new NPP or the new system and carry out their activities in the best possible conditions of safety.

In 2008, with the support of IRSN, ASN continued with its review of EDF's implementation of this approach in the design of the EPR reactor at Flamanville.

ASN in particular asked IRSN to review:
– the organisation proposed by EDF for the new reactor operations team;
– the ergonomic validation programme to be performed by EDF during the simulator tests scheduled for 2009;
– the steps taken by EDF to incorporate HOF into the design of premises and equipment which, during operation, will require in-situ interventions.

The conclusions of this work will be presented in 2009.

Incorporating HOF into the plants in operation

With regard to HOF resources and skills, ASN observed during its regulatory actions that the number of human factors consultants in the NPPs sometimes needed to be increased to ensure satisfactory performance of all HOF related actions. Moreover, the number of these consultants with a technical or management background has increased to the detriment of those with expertise in human and social sciences. Finally, some NPPs still do not have a local network of human factors correspondents in the core disciplines. Where these networks do exist, ASN considers that the required training should be attended by all members of the network, which is not always the case.

In 2008, EDF presented its new HOF skills management policy to ASN, the main aims being to increase the number of human factors consultants on NPPs, a better balance between human sciences and technical or engineering profiles and, finally, a higher level of professionalism based on an inter-company master's degree in HOF aspects of safety management, which will be a promotion opportunity for both staff and managers. ASN will monitor implementation of this new policy nationally and locally on NPPs.

EDF's national "human performance" project is currently being deployed. The project comprises two parts: to make interventions more reliable and to increase management presence in the field. On the whole, all NPPs are highly mobilised and all the staff concerned by these tools have been trained. However, ASN observed that even though the staff are now familiar with the tools designed to improve the reliability of work done, their actual implementation remains patchy, and are sometimes met with hesitation or perplexity or used with no real conviction. The efforts made by NPPs to ensure practical implementation of these tools, in particular during training sessions on simulators or on training worksites, must be continued. It is the DPN's intention to train correspondents in the various departments to help with deployment of these tools.

The DPN has initiated a programme to train its contractors in the use of these tools in order to improve the quality of their work. DPN's goal is to train half of the contractors concerned by the end of 2009.

NPPs are still actively working on increasing management presence in the field, as part of the "human performance" project. Manager training in field visits is ongoing on most NPPs. Targets in terms of the number of visits to be made are set for the managers but are rarely achieved. Given the large number of constraints to be managed and given the high workload and sometimes overwhelming administrative tasks they have to accomplish, the managers have difficulty reaching these targets.

For ASN, quantitative targets are without doubt useful for setting points of reference, but they should not lead to a policy dictated by figures alone: a larger number of cursory or over-targeted visits would run contrary to one of the aims of the field visit, which is to make the work easier, implying a both open and in-depth observation of what is happening in work situations.

To make it easier to collect and analyse information feedback from the observations made by the managers during the field visits, a software programme has been made available to all NPPs. ASN will check the use of this tool and the corresponding lessons learned.

Analysis of HOF causes in operating experience feedback from reactors in operation

The search for underlying HOF causes in the events notified to ASN is an essential means of improving safety. The depth and scope of the analysis determine the licensee's ability to learn lessons from operating experience feedback in order to improve safety.

When an in-depth analysis of an event is made by IRSN, it frequently reveals that the HOF causes have not been considered by the licensee. ASN considers that the efforts made by the licensees to improve how HOF factors are included in the events analysis must be continued. EDF has provided NPPs with a database software tool for collecting and analysing HOF causes and producing a nationwide summary. As of 2009, ASN will more particularly check the use of this tool and the lessons learned both locally and nationally.

The GPR also met at the request of ASN in order to review the operating experience feedback from the EDF reactors in operation for the period 2003-2005. The review highlighted considerable implication of HOF in the events over this period, especially during reactor outages. It also showed that EDF was more effective in detecting and dealing with anomalies.

Nearly one third of the events analysed involved communication and cooperation problems. One of the aims of EDF's national "human performance" project is to have all stakeholders adopt proven and recognised communication practices. ASN considers that operating experience feedback will soon be required concerning implementation of the measures adopted, in order to check their effectiveness. It asked EDF to send it the corresponding results.

The shift change is also an important moment for transmitting clear information between each of the 8-hour shifts. Smooth changeover and preparation for the next shift can be compromised by excessive time pressure and a large number of concurrent activities, particularly during reactor outages. ASN asked EDF to examine the relevance of the measures adopted to ensure quality shift changes when there is significant time pressure, and to forward the results to it.

Finally, among the events notified in 2008, ASN observed a large number of faults related to ergonomics: documents, equipment and premises (inappropriate or obsolete equipment, equipment marking or positioning errors, accessibility problems), ergonomically inadequate IT tools leading to the creation of alternative tools that are less secure. ASN also observes that errors resulting from confusion are frequent on NPPs, even though they do not all lead to deviations: confusion between buttons on the control room console, systems or equipment confusion, confusion between documents and even confusion between the premises of two reactors. These errors are not all due to inattention on the part of the individuals concerned. On the contrary, in some cases, the operator was misled by a lack of signage or labelling on the equipment concerned. More broadly however, a large number of the lines of defence need to be strengthened. This first of all involves the cleanness of the NPPs in order to ensure that the labels and markings are easily legible. It also involves means such as the use of coding to ensure clear differentiation between premises or equipment (colour-coding for instance), optimisation of the marking systems used in various areas and improved signage. Working environment conditions (lighting of premises and equipment) also help improve the legibility of the markings and signage. ASN will query the licensee about the improvement measures taken or planned, in terms of the ergonomics of the NPP equipment and premises, particularly as part of its national project entitled "Achieving exemplary installation conditions".

2 | 1 | 2 Management of employment, skills, training and qualifications within EDF

Skills and qualifications

Control of BNI safety rests on the ability of the licensee's management system to ensure that appropriate skills and adequate resources are available at all times during the life of the NPP. Article 7 of the order of 10 August 1984 in particular requires that "only individuals with the required skills may be assigned to an activity affecting quality" (see point 2|2).

Skills

Skills encompass a range of knowledge, know-how, abilities and standard behaviours, through which an individual is capable of providing a relevant response in a given situation. They involve theoretical knowledge enabling the individual to comprehend what is actually happening, procedural knowledge concerning how to act and practical operating knowledge linked to experience of working situations. They also involve the individuals' awareness of their own abilities and limits in normal and degraded situations, built up through the accumulation of experience. Skills are therefore acquired and structured. They are also creative, in other words they go beyond simply carrying out specific actions and enable the person to anticipate events, to adapt and deal with a wide variety of situations, even unexpected ones.

Skills can be individual, but also collective, with the activities being carried out in situations requiring interaction between the persons concerned. Implementing the skills and experience acquired through repeated interaction leads to the emergence of a collective competence. The collective aspect of the activity involves shared understanding and knowledge, mutual coordination and monitoring procedures and specifically collective practices and codes, which contribute to shaping the common knowledge and know-how, for example within a team or work shift.

Finally, it is important to take account of two other aspects of skills. A skill is on the one hand an abstract notion that cannot be observed. It is in fact only possible to observe the manifestations of the skills, in other words how they are mobilised during actual activities (using a tool, software or method, operating equipment, using knowledge to solve a new problem and so on). Furthermore, skills are not eternal and cannot be maintained without practice.

Skills management

For activities involving risks, as is the case in a BNI, it is essential to set up a skills management system to ensure that the licensee has an appropriate and adequate level of skills at all times.

It is the licensee's responsibility to organise the management of its skills. ASN considers that a system such as this must allow management of the skills as a whole, from identification of the skills necessary for performance of the activities, up to assessment of the skills deployed, through determination of requirements and the appropriate action being taken in terms of training practice, recruiting or subcontracting. The management system must enable the licensee to anticipate skills renewal in order to guarantee that the necessary skills will be available at all times, regardless of the number of staff departures.

At an international level, the skills management approach proposed by IAEA is based on a "systematic approach to training (SAT)" presented as a five-step process comprising a continuous improvement loop, from analysis of tasks and training requirements up to training evaluation and regular skills checks. IAEA underlines the need to develop non-technical skills (team working, communication, safety culture, etc.) not only for the managers, but also for all the staff involved.

Qualifications

The qualification issued by the licensee proves an individual's ability to perform given activities. ASN considers that qualification must be based on justification of the skills acquired through training and professional experience and the skills demonstrated in performance of the professional discipline concerned.

A training session in an EDF nuclear power plant

ASN regulation

Pursuant to Article 7 of the order of 10 August 1984, ASN monitors the quality of the employment, skills, training and qualifications management system and its deployment in the EDF NPPs. This monitoring relies in particular on the inspections carried out in the plants. They are an opportunity to analyse the results obtained and the quality and the adequacy of the organisational and human arrangements actually made with regard to these issues. ASN also uses the assessments made at its request by IRSN and the GPR.

ASN's monitoring highlights a situation that is on the whole satisfactory. The organisation in place on NPPs for managing skills and qualifications appears to be satisfactory and the management processes are well documented and coherent. Considerable efforts have been made by NPPs, but implementation of these processes in the departments is sometimes lacking in rigorousness and uniformity, for example with regard to skills mapping. Problems have been observed in attaining the goals set concerning managerial presence in the field for observation of the work situations in order to evaluate staff skills in a real situation. Finally, anomalies with updating the individual career logs were also observed.

Inadequacies were recorded in various areas:
– with regard to radiation protection, in the training of EDF but also contractor staff who, on the worksites, are insufficiently aware of the risks and preventive measures concerning ionising radiations;
– in the field of environmental protection, the training sessions would seem to be more about information and awareness raising, as there are no subsequent refresher courses. The training of the contractors could also be improved;
– in the field of transient bookkeeping, insufficient staff and a lack of advance planning in skills renewal;
– training scheduled but not carried out for PUI duty personnel;
– shortcomings in training of the staff responsible for contractor surveillance.

Anomalies were also observed in supervision of operating personnel training. Moreover, the "accident operations" and "earthquake" training for the operating personnel needs to be improved. The arrangements made for tutor-based training of a member of staff or providing him/her with support when performing an activity for the first time, also need to be improved.

Finally, a lack of practice with new operating documents can lead to events, which can be significant.

At a national level, EDF is currently running a number of general projects, including:
– discipline academies;
– training worksites and field visits by managers;
– simulators;
– skills mapping.

Discipline academies

In 2007, EDF presented ASN with its project for the creation of discipline academies, to share the initial training of new recruits among several NPPs, but also to ensure that this training better reflects reality, in particular by having the trainees supervised by professional tutors and by frequently alternating between theoretical work in the classroom and practical work in the field. A process of gradual qualification also aims to make the new employee increasingly accountable for his or her actions as training progresses. These arrangements were put into place in 2008 and concern all new recruits in the operating disciplines, and more recently in the automation disciplines. Their use will be extended to other disciplines and to a number of contractors in the coming years. ASN considers that this work was correctly planned and implemented, but that EDF must verify the adequacy of the means and resources, particularly instructors and tutors, deployed to manage the trainees.

Training worksites

The training worksites are intended for training of field operators, technicians and engineers. They generally comprise several standard worksites (valves, mechanical parts, etc.) on which the staff can practice and acquire specific reflexes and skills. ASN notes that EDF uses these training worksites to develop and consolidate skills that are important for the workforce: maintaining or acquiring rare skills or abilities, the development of practices to enhance the reliability and safety of the work, the development and implementation of postures and attitudes of use for observing, facilitating and interacting with the other operators. These worksites do not only concern the field operators, but also the management, radiation protection, safety and maintenance disciplines. ASN considers the creation of these training worksites to be beneficial for skills development and will be monitoring their deployment.

Simulators

Since 2004, EDF has had a full-scope simulator on each NPP, intended for training the operating teams. ASN notes that the level of use of these tools is generally highly satisfactory. Their success does however lead to a number of problems with session scheduling that need to be resolved by EDF.

Skills mapping

For EDF, skills mapping is an essential tool in forward-looking management of employment and skills. It is a means of monitoring the evolution of the adequacy

Use of a self-checks during a training session on a training worksite

between the skills and manpower requirements for a department, discipline or NPP and those actually available. This work is generally done by competent correspondents fully familiar with their professional discipline, their NPP or their department. It is a means of identifying the skills and manpower available at any given moment, but also of looking several years ahead and thus defining targets for training and hiring of new staff. During the inspections carried out by ASN, the quality of these maps is examined by means of spot-checks. ASN notes differences in the methodology used and in the quality and the level of progress made by the departments and disciplines on this point. It also observes that the action plans defined on certain NPPs with regard to training and hiring, sometimes make insufficient use of these skills maps.

2 | 1 | 3 Safety management

The safety management domain

In its INSAG 13 document "Management of Operational Safety in Nuclear Power Plants" published in 1999, IAEA gives the following definition: "The safety management system comprises those arrangements made by the organization for the management of safety in order to promote a strong safety culture and achieve good safety performance".

Safety management concerns the steps a licensee must take to establish its safety policy, define and implement a system allowing the safety of its NPP to be maintained and constantly improved. It is based on a process of continual safety improvement incorporating:

– definition of requirements, of an organisation, or roles and responsibilities, of means and resources, particularly with regard to skills;
– preparation and implementation of arrangements for guaranteeing or enhancing safety;
– monitoring and evaluation of the implementation of these arrangements;
– improvement of the system on the basis of the lessons learned from the inspections and assessments carried out.

For ASN, the safety management system must provide a framework and support for the decisions and actions which either directly or indirectly concern safety issues. The safety management steps taken by the licensee must lead to decisions and actions that promote safety. They must also convey a message that enables the stakeholders to give safety the importance it deserves. Finally, it must be possible to compare them with the results achieved, to allow continual improvement and to ensure that safety progresses.

As a part of the company's overall management system, safety management is an indicator of how the company expresses the values underpinning safety, for example "safety is everyone's business", "safety is a priority". Secondly, the safety policy clarifies how safety is achieved; it sets objectives, defines a strategy, and allocates means and resources. Thirdly, technical, organisational and management steps are taken to achieve these objectives, for example in the form of operating documents, guides, methods and tools. Finally, these steps are reflected in practices, attitudes and the inclusion of safety considerations in the day to day activities in the NPP. Steps are also taken to ensure top-down communication enabling the global vision and values, objectives, procedures and guides to be disseminated, along with bottom-up communication to transmit the information learned from implementation of the system in the field with a view to continual improvement. Finally, steps are taken to ensure the monitoring and evaluation of the implementation of safety management arrangements on a day to day basis.

ASN regulation

The order of 10 August 1984 (see point 2|2|1 in chapter 3) contains requirements with which the licensee must comply in order to define, obtain and maintain the quality of its NPP and its operating conditions. These requirements in particular concern the organisation that the licensee, as the party responsible for its NPP, must put into place in order to control the activities affected by quality, in other words to obtain and guarantee safety.

ASN considers that safety management must be a part of the general management system, to ensure that safety is given consideration in the same way as the other interests protected by the TSN Act, such as radiation protection, environmental protection, but also the security of the electricity grid, the guaranteed supply of electricity to the country, as well as the cost control, NPP availability or corporate competitiveness objectives.

In 2008, ASN, with its technical support organisations, IRSN and the GPR, reviewed EDF management of the safety of its reactors in a competitive context and how it was implemented in the NPPs.

Generally speaking, ASN considers that in a competitive context, the steps and practices employed by EDF should be able to take account of safety requirements and continue to improve operating safety.

ASN observes that EDF has gradually built up a management system that incorporates safety around principles such as quality-focused management, continuous improvement, management of operating experience feedback, stringent working practices, inclusion of HOF, complementary inspections and checks and individual commitment. These principles were developed in arrangements which today constitute the foundation of the EDF safety management system.

ASN observes the momentum that today drives safety issues, the commitment to safety by all the stakeholders, EDF's ability to create specific project structures in order to break down the internal barriers within its organisation when needed, the complementarity of the inspections and checks arrangements and the diversity of viewpoints contributing to the decision-making process.

However, ASN asked EDF to take additional action on the following points:

– to give more actual priority to safety in certain real-time decision-making situations, where simultaneous reconciliation of safety, radiation protection, environmental protection, availability, work organisation, cost, etc. objectives can lead to a relative loss of visibility of the safety requirements and can influence the decisions to be taken;
– to reduce sources of disruption or the various changes such as the greater time pressure on the decisions made, the growing complexity of the specifications, the resource optimisation approach, structural and social constraints and the occasional external constraints highlighting the vulnerability of the management system, which can hinder the continuous improvement of NPP safety;
– to reinforce the robustness of the safety management system by introducing "breathing space" for the stakeholders, taking the form of periods of stability in change management and in the overall improvement process;
– to identify the potential impacts on safety management arrangements of the deep cultural changes faced by the licensee, owing in particular to the renewal of its workforce and the trend towards a performance-oriented culture. The robustness of the safety management system is also based on the significance that the operational players attach to safety and, more generally, the safety management system is built around a culture that is constructed gradually with the existing staff;
– to enhance the position of the shift operations team during reactor outages. The shift operation team is responsible for real-time operations, particularly with regard to safety. The operation staff must at all times be able to assume this responsibility, whatever the constraints and demands they face during reactor outages. They do not however always have the time and means necessary to prepare and justify their position in response to the demands and proposals made by the members of the structure in charge of the reactor outage;
– the impact on the managers of greater pressure arising from escalating requirements. The escalation in requirements applying to all fields such as safety, radiation protection, availability, the environment, security and cost is occurring in a context of numerous constraints linked in particular to the ageing of the NPPs, skills renewal, resource optimisation and the new regulations. Managerial commitment to a large extent determines the extent to which these various requirements and constraints are coped with. The pressure to which they are subjected in the situations they face can lead to compensation phenomena which could compromise the managers' ability to make the correct decisions. This risk needs to be analysed and addressed.

ASN also underlines the importance of implementing an operational approach at all management levels within the company, based on the INSAG 18 document "Managing Change in the Nuclear Industry: The Effects on Safety" published by IAEA in 2003, to analyse the impact of organisational changes.

Finally, ASN notes that the topic of familiarity with and implementation of the technical and organisational rules and requirements was a recurring theme throughout this review and attaches particular importance to EDF giving thought to the effects of the complexity of all the specifying documents on the ability of the operational staff to comprehend what they contain.

ASN considers that the significant events notified by EDF as part of the operating experience feedback system sometimes reveal failures in the arrangements made to control the quality of the safety-related activities: lack of a questioning attitude, incorrect decision-making without involvement of the safety engineer, checks not carried out, initiatives taken without appropriate risk analysis, lack of independence on the part of a member of the independent safety line, etc. The context itself is sometimes a contributory factor in the event, such as postponement of activities or time pressure.

Safety and competitiveness

To improve safety management, the "Safety Radiation Protection Availability Environment Observatory" (OSRDE) set up by EDF about ten years ago offers analysis of how safety is taken into account when decisions are made, by comparison with other demands, such as NPP availability, radiation protection or environmental protection.

ASN considers that this is an essential tool in examining and continuously improving the decision-making processes. However, as in previous years, ASN observed that this tool is as yet little used or inconsistently used by the NPPs. ASN also considers that participation by the representatives of the disciplines relating to aspects other than safety, in particular radiation protection and environmental protection, is important if the decision-making process is to be analysed in the light of the various requirements.

Furthermore, the review of safety management by EDF in a competitive context, as presented at the GPR meeting of April 2008, showed that the OSRDE is currently only reviewing whether the decision-making process complied with quality criteria – in particular calling on the appropriate support structures, with the decision being taken at the right level – without calling into question the adequacy of the decision itself. This limits the analytical capacity of the system. For the OSRDE to be a means of effectively advancing the decision process, this system must also look at the adequacy of the decisions taken, particularly through a review of the elements on which they are based, such as information, context, stakeholders, the skills and support structures mobilised. Following this review, ASN asked EDF on the one hand to improve the OSRDE system and, on the other, to make better use of it in order to constitute an effective organisational operating experience feedback tool.

2 | 1 | 4 Monitoring the quality of subcontracted operations

Maintenance of the reactors in the French NPPs is to a large extent subcontracted by EDF to outside companies. This activity involves about 20,000 contractors and subcontractors.

Implementing an industrial policy such as this is left to the initiative of the licensee. Pursuant to the order of 10 August 1984, mentioned in section 2.2.1 of chapter 3, ASN's role is to ensure that EDF assumes its responsibility for the safety of its NPPs, by implementing a quality approach, and in particular by monitoring the conditions in which this subcontracting takes place. This approach is officially laid out in the "Progress and sustainable development charter" signed by EDF and its main subcontractors.

Selection and monitoring of the activities performed by the contractors

EDF has set up a contractor qualification system based on an assessment of their technical know-how and their organisation. In addition, EDF is required to monitor its contractors' activities, or have them monitored, and use operating experience feedback for a continuous assessment of their qualification.

In 2008, ASN carried out inspections on the implementation of and compliance with EDF contractor monitoring requirements in the NPPs. ASN noted the considerable efforts made for a formally defined and robust quality and safety organisation. ASN did however observe discrepancies between NPPs and within their various departments in terms of the monitoring practices and a lack of stringency in the use and filling out of the documents necessary for contractor monitoring. ASN also considers that EDF needs to maintain its efforts to ensure that the resources allocated to monitoring are appropriate to the number of interventions to be monitored.

ASN also considers that worksite organisation could be improved further and in 2008 it observed discrepancies in the preparation and coordination of the worksites, problems with the provision of tools and individual protection equipment, difficulties concerning access and intervention, and quality shortcomings in the documentation supplied to the contractors.

Intervention conditions

With regard to the intervention conditions, ASN feels that on the basis of the inspections performed in 2008, EDF needs to further improve the quality of the monitoring programmes, in order to check effective implementation on the worksites of the compensatory measures identified in the risk assessments, the quality of which could also be improved.

Radiation protection and conventional safety

In terms of radiation protection for workers, ASN focused its attentions on enforcing the Labour Code through inspections conducted during the reactor outages. ASN in particular ensured that exposure to ionising radiation was checked with the same level of quality, regardless of whether the work was done by contractors or by EDF employees. It also ensures compliance with the rules concerning work in a contaminated environment and the radiological cleanness levels of the premises.

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.

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

In 2008, ASN therefore commissioned an expert assessment of the nuclear contractors from an independent firm. It will analyse the conclusions of this assessment to help guide its regulation of EDF starting in 2009.

2 | 1 | 5 Operations subject to enhanced supervision by the licensee

ASN requested that EDF apply a system of enhanced internal supervision to certain operations it felt to be particularly sensitive in nuclear safety and radiation protection terms. "Internal authorisation" arrangements (see chapter 4, point 2|1|1) were thus approved by ASN for the following operations:
– 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.

Authorisations in these two areas can only be issued by EDF management or the management of the NPP concerned, following a review by an independent internal body comprising the safety and quality managers. EDF also checks the working of these processes and reports on them to ASN.

2 | 2 Continuous safety improvements

2 | 2 | 1 Correction of anomalies

Anomalies are detected in NPPs through the systematic checks required by ASN and proactive measures taken by the licensee. EDF is cultivating a questioning attitude whereby it takes the initiative to look for anomalies.

ASN requires that anomalies with an impact on safety be corrected within a time-frame commensurate with their severity.

It considers that periodic reviews and a continuous search for anomalies by the licensee help guarantee an acceptable level of safety.

Systematic checks: conformity reviews

EDF carries out periodic safety reviews on the nuclear reactors every ten years (see point 2|2|3). EDF thus compares the actual condition of the NPPs with their applicable safety requirements and identifies any anomalies. These anomalies can have a variety of origins: design problems, construction defects, nonconformities introduced during preventive or corrective maintenance operations, deterioration caused by ageing, and so on.

A review of the reference design studies is therefore an opportunity to detect and deal with any anomalies. This review is carried out by the EDF engineering centres, draws on the latest updated knowledge and takes advantage of the latest design methods used in the field of reactor operations. This review includes a check on the conformity of the measures taken for protection against external hazards, such as extreme meteorological conditions (particularly heat waves) and earthquakes. The conformity of protection against internal hazards, such as high-energy line breaks, is also examined. In addition, the licensee ensures that the equipment is still able to function in the degraded ambient conditions liable to occur in the event of an accident (referred to as "accident conditions qualification"). These checks are supplemented by a programme of additional appraisals. The aim is to check those parts of the NPPs which are not covered by a preventive maintenance programme owing to the difficulty involved in accessing them.

One particular aim of the conformity reviews on the various EDF reactors is to track down any generic anomalies that could simultaneously affect reactors of similar design.

"Real time" checks

ASN considers that the questioning and analytical attitude adopted by EDF needs to be maintained and indeed strengthened. This approach effectively completes the systematic anomaly tracking process. For example, routine field visits are an effective means of discovering faults. The performance of periodic test and preventive maintenance programmes on the equipment and systems also helps identify these anomalies.

Informing ASN and the public

The public is informed of the most significant conformity anomalies (INES scale level 1 and higher) by means of ASN's website.

An upstream system was created to ensure that ASN is specifically informed of any conformity anomalies discovered by EDF. When there is any doubt concerning the conformity of an equipment item, EDF notifies ASN accordingly. At the same time, the licensee attempts to characterise the problem encountered. The purpose of this characterisation is to determine whether there is really any nonconformity with regard to the safety requirements defined during the design process. If so, EDF specifies which equipment is affected and evaluates the safety consequences of the nonconformity. ASN is notified of the results of this characterisation. As applicable, EDF sends it notification of a significant safety event.

This procedure guarantees transparency with regard to both ASN and the public.

ASN's remediation requirements

Any conformity anomaly which significantly impairs safety must be corrected rapidly, even if the remedial measures entail a large volume of work. This is why ASN reviews the remediation methods and time-frame proposed by EDF. To carry out this review, ASN takes into consideration the actual and potential safety consequences of the anomaly. ASN cannot authorise restart of the reactor or decide to shut down the NPP until the repair has been completed. This is the case if the risk involved in operation while the anomaly is present is considered to be unacceptable and if there is no appropriate remedial measure. Conversely, the lead-time allowed for correction of a less severe anomaly may be increased when so justified by particular constraints. These constraints may be linked to operational safety. They may also arise from national and European electricity grid security objectives.

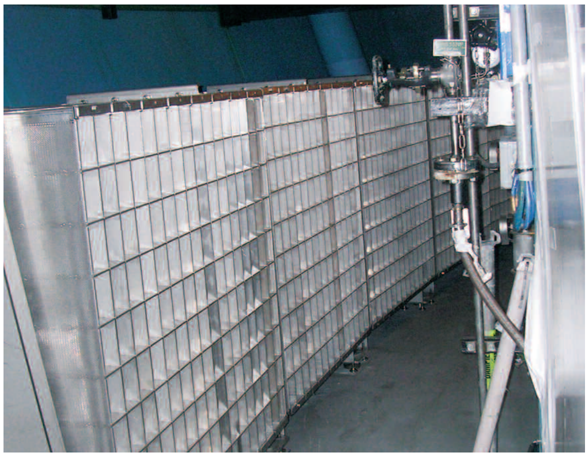
For example, for earthquake resistance anomalies, one factor in assessing the urgency of the repair is the seismic level for which the equipment in question is designed. In cases in which there is only a need to restore a safety margin for an equipment item which can already withstand a large-scale earthquake,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

2 | 2 | 2 Review of events and operating experience feedback

The general process for incorporating operating experience feedback

Operating experience feedback is a major source of improvement in terms of safety, radiation protection and the environment. This is why ASN requires that EDF notify it of significant events occurring in the NPPs. Criteria for notification of the authorities were defined for this purpose in a document entitled "guide to notification procedures and the codification of criteria concerning significant events in terms of safety, radiation protection or the

Recirculation sump filter



Close-up of recirculation sump filters

The anomalies currently being dealt with

Anomaly affecting the recirculation sump strainers

In certain accident situations, the recirculation function is used to cool the reactor core and reduce the pressure and temperature inside the containment. The recirculation sump strainers located at the bottom of the reactor building collect the water injected by the RIS and EAS systems (see point 1|1|5) during recirculation.

In 2003, following an ASN request for a review of the risk of clogging of the recirculation sump strainers, based on international operating experience feedback, EDF notified a generic anomaly concerning this phenomenon.

As of 2006, EDF initiated replacement of all the sump strainers, with the aim of completing the conformity work in 2009.

After a review of the recirculation design studies, EDF informed ASN in 2007 that some of the recently installed filters failed to comply with the requirements of this review. However, steps taken by EDF in 2006 to replace the filters led to an improvement in the level of safety when compared with the situation in 2004.

In 2007, EDF defined a new filter design. Its implementation by 2009 remains in line with the initial undertaking. To date, of the 58 reactors affected, 45 are in conformity and conformity work on the remaining 13 reactors will be completed in 2009.

The sump clogging phenomenon affects all of the world's pressurised water reactors. France is helping to address the risk of clogging of these filters. The results of the experimental research programme conducted by IRSN on this phenomenon and the positions adopted by ASN contribute to the international debate on this issue. In order to share information about the risk of sump strainer clogging with its foreign counterparts, ASN organised a seminar in December 2008, in collaboration with the OECD's Nuclear Energy Agency. This seminar enabled the various countries to discuss regulatory practices, existing industrial solutions, future research projects and issues as yet unresolved.

Anomaly concerning the steam generator feedwater system piping

On 28 May 2008, EDF informed ASN of an anomaly on the ASG piping supports on certain 900 MWe reactors. The ASG system supplies the water the steam generators need to cool the reactor in the event of failure of the normal SG feedwater system. This system is also used during the reactor start-up and shutdown phases. This anomaly concerns reactors 2 and 4 at Le Blayais, Chinon, Cruas-Meysse, Dampierre-en-Burly and Tricastin, reactors 2, 4 and 6 at Gravelines and reactor 2 at Saint-Laurent-des-Eaux.

EDF calculated that the integrity of the ASG system piping could be jeopardised in the event of an earthquake. This anomaly was notified as a significant safety event and was rated level 1 on the INES scale.

On 31 July 2008, ASN asked EDF to restore the conformity of the ASG system piping supports within a few months. In September 2008, EDF undertook to restore the conformity of the fourteen reactors affected by April 2009.

environment, applicable to BNIs and radioactive material transport". Each significant event is rated by ASN on the International Nuclear Events Scale (INES), which comprises eight levels from 0 to 7.

Both locally and nationally, ASN reviews all significant events notified. For certain significant events felt to be most important, because of their noteworthy or recurring nature, ASN has a more in-depth analysis carried out by IRSN.

ASN oversees how EDF utilises operating experience feedback from significant events and uses it to improve safety, radiation protection and environmental protection. During inspections in the NPPs, ASN also reviews the organisation of NPPs and the steps taken to deal with significant events and take account of operating experience feedback.

ASN also ensures that EDF learns lessons from significant events that have occurred abroad.

Finally, at the request of ASN, the GPR periodically reviews operating experience feedback from the operation of pressurised water reactors. The GPR met on 20 December 2007 to review the significant events of the 2003-2005 period, in particular concerning events that were significant in terms of radiation protection, the operation of equipment classified as important for the safety of 1300 MWe reactor control, the operation of ventilation systems and analysis of operating stringency in certain situations and for certain maintenance work.

Subsequent to this review, ASN considered that the safety of EDF's reactors in operation did not deteriorate over the period 2003-2005. However, a review of operating experience feedback revealed new or recurring problems for which ASN asked EDF to carry out an in-depth analysis.

Significant events in 2008

In accordance with the rules for notification of significant events in terms of safety, radiation protection and the environment, EDF notified 737 significant events in 2008, rated on the INES scale, including 628 relating to safety and 109 relating to radiation protection.

The significant events notified with respect to environmental protection and which concern neither nuclear safety nor radiation protection, are not rated on the INES scale. Eighty-six significant events were notified in this respect in 2008.

Graph 1 shows the trends in the number of significant events notified by EDF and rated on the INES scale since 2004.

The total number of significant events rated has been appreciably the same since 2005.

Graph 2 shows the trends since 2004 in the number of significant events per area concerned by the notification: significant safety events (ESS), significant radiation protection events (ESR), and significant environmental events (ESE).

The graph shows that the number of ESS and ESR is approximately unchanged since 2006. However, the number of ESE rose sharply in 2008.

The proportion of the number of ESS rated level 1 on the INES scale as compared with the total number of significant events rated in the year is about 10%, an increase over 2007, with 72 significant safety events rated and none for radiation protection. The total number of significant events rated level 1 is the same as the level reached in 2006.

The average number of events rated levels 1 and 0 per year and per type of reactor, varies according to the plant series, as shown in graph 3. There has been no particular change in relation to 2007 for the 900 MWe reactors and the N4 reactors. However, a slight rise is observable for the 1300 MWe reactors.

2 | 2 | 3 Periodic safety reviews

Article 29 of the TSN Act requires that the licensees (II) periodically conduct a safety review of their NPPs. This review is carried out every ten years, unless the authorisation decree (DAC) for the NPP mentions a different frequency, as justified by the specific characteristics of the NPP.

The periodic safety review is an opportunity for an in-depth examination of the condition of the NPPs, to check that they comply with all the safety requirements and the applicable safety provisions. Its objective is also to improve the level of safety, particularly by comparing the applicable requirements with those applied to more recent NPPs. Following the safety review a number of equipment or operating modifications is defined in order to correct any anomalies and improve the level of safety.

The periodic safety reviews therefore constitute one of the cornerstones of safety in France, by obliging the licensee not only to maintain the level of safety of its NPP but also to improve it.

The review process

The periodic safety review comprises a number of successive steps.

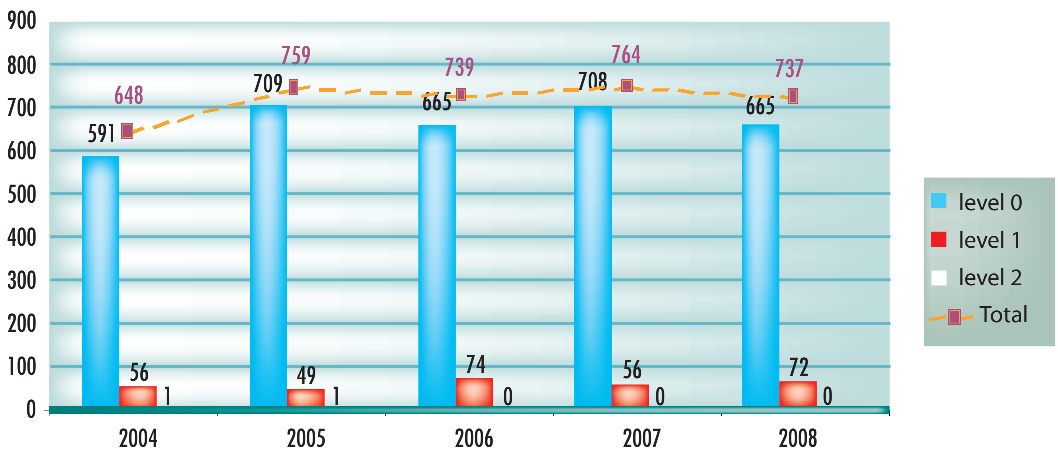
1. Comparison between the condition of the NPP and the applicable safety requirements: this is the conformity review. The aim is to identify any deviations during construction or during any modification of the NPP.

2. The review of the safety requirements applicable, by comparison with the best international practices or the most recent safety standards. Possibly after consulting the GPR, ASN may rule on the study topics envisaged by the licensee before the launch of the safety review studies. This is the review orientation phase.

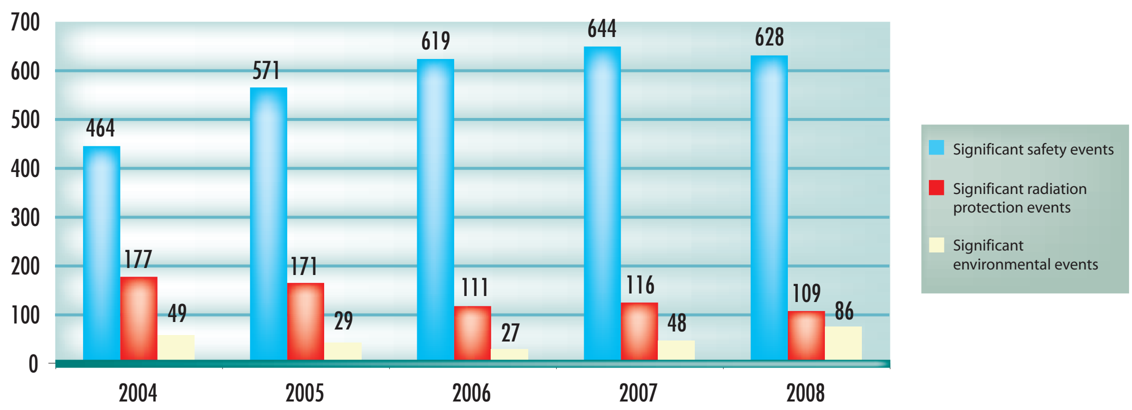
3. Definition of a set of equipment and operational modifications designed to correct the anomalies and significantly improve the level of safety, in order to establish new "safety requirements". The reactor ten-yearly outages (see point 1|2|3) are a particularly suitable moment for carrying out these modifications.

4. Following these three steps, the licensee sends ASN a review report containing the conclusions of its installation safety review. This report in particular states the measures the licensee intends to take to improve the level of safety in the NPP or to remedy any deviations detected. ASN sends the ministers responsible for nuclear safety and radiation protection its analysis of the report and may require that the licensee follow additional requirements.

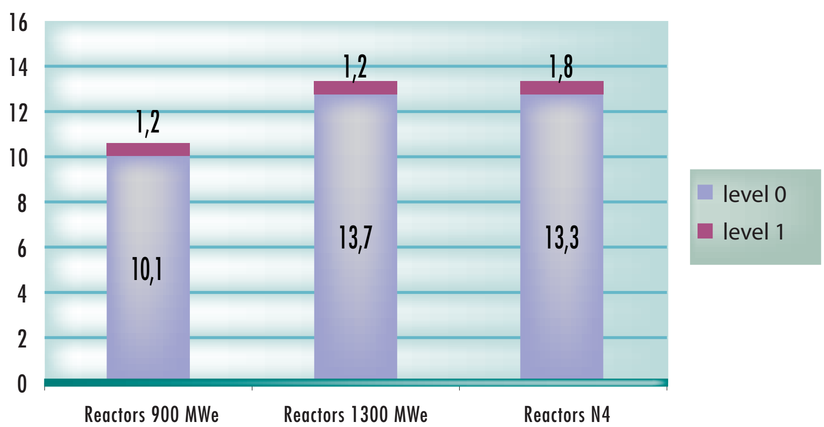
Graph 1: changes in the number of significant events rated on the INES scale in EDF nuclear power plants from 2004 to 2008



Graph 2: changes in the number of significant events per domain in EDF nuclear power plants from 2004 to 2008



Graph 3: average number of significant events rated on the INES scale in the EDF nuclear power plants per type of reactor for the year 2008



The twenty-year safety review for the 900 MWe reactors

The twenty-year safety review for the 900 MWe reactors was completed in 2002. ASN then declared itself to be in favour of continued operation of the 900 MWe reactors until they are thirty years old. The changes resulting from this safety review will be completed in 2010 during the second ten-yearly outage of Chinon reactor 4.

Of the changes implemented by EDF, it is worth mentioning those designed to improve the reliability of the standby turbine generator, the ASG system (see point 1.1.5) or the ventilation systems of premises housing safeguard equipment.

The thirty-year safety review for the 900 MWe reactors

After defining the orientations of this safety review in 2003, ASN consulted the GPR at the end of 2004 and in the first half of 2005 with regard to the various study topics selected, including serious accidents, containment, fire, explosion and the use of probabilistic safety studies. Following these consultations and based on the recommendations of the GPR, ASN asked EDF to look at whether additional modifications were appropriate, such as the study of a floating dam type device designed to slow down or even stop any spread of pollutants, and to conduct additional design work.

ASN also asked EDF to describe the principles and methods involved in controlling the internal explosion risks on NPPs, in a specific chapter of the safety analysis report. At the end of 2008, ASN started to examine the conclusions of this safety review, so that it can adopt a stance on the action taken at national level by EDF. Implementation of the modifications arising from this safety review is scheduled for the third ten-yearly outages on the 900 MWe reactors, from 2009 to 2020.

The twenty-year safety review for the 1300 MWe reactors

In 2006, subsequent to the safety review, ASN declared itself to be in favour of continued operation of the 1300 MWe reactors up to their third ten-yearly outage. It will take until 2014 to implement the changes arising from this safety review.

In 2008, the Cattenom 2, Flamanville 1 and 2, Paluel 4 and Saint-Alban 2 reactors incorporated the changes following their second ten-yearly safety review.

The ten-year safety review for the 1400 MWe reactors

In 2008, ASN ruled on the orientation of the first periodic safety review for the N4 reactors, which in particular concerns the level 1 probabilistic safety studies and the hazards studies. The first ten-yearly outages for the N4 reactors designed to incorporate the modifications resulting from the review, will take place as of spring 2009.

2 | 2 | 4 Modifications to equipment and to operating rules

As part of the process of continuous improvement of the safety of its reactors, but also to improve the industrial performance of its production tool, EDF periodically makes changes to equipment and operating rules. These changes can for example be the result of correction of nonconformities, periodic safety reviews, or to take account of operating experience feedback. Decree 2007-1557 of 2 November 2007 clarified the requirements concerning implementation of changes by EDF and their review by ASN.

In 2008, the equipment change notifications received by ASN were primarily aimed at improving reactor safety. One change concerned the software in a reactor I&C unit. After analysis of the various files by IRSN, ASN issued approval for the changes with a minor or favourable impact on safety.

Documentary changes are subject to prior notification to ASN under Article 26 of the above-mentioned decree when they concern chapters III, VI, VII, IX or X of the general operating rules, presented in point 1|2|2. The main documentary changes dealt with in 2008 are presented in points 3|1|1, 3|1|2 and 3|2|4.

2 | 3 NPP ageing

NPPs, like all industrial installations, are subject to ageing. ASN's role in this area is to ensure that, in line with its general operating and maintenance strategy, EDF takes account of ageing-related phenomena in order to maintain a satisfactory level of safety throughout the life of the NPPs.

2 | 3 | 1 The age of the French NPPs in operation

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

In December 2008, the average age of the reactors, calculated from the date of initial reactor criticality, was as follows:

– 27 years for the thirty-four 900 MWe reactors;

– 21 years for the twenty 1300 MWe reactors;
– 11 years for the four 1450 MWe reactors.

2|3|2 Main factors in ageing

To understand the ageing of a NPP, 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
The design of a number of reactor components was based on a predetermined operating period. These components require close surveillance ensuring that their ageing rate is indeed as expected. This is particular the case with the reactor vessel, designed to withstand embrittlement of the core zone steel as a result of neutron irradiation for at least 40 years (equivalent to 32 years of continuous operation at full power). The reactor vessel is checked by monitoring "control samples" of metal and appraising them at regular intervals (see point 3|4|3).

Deterioration of replaceable items
Equipment ageing is the result of phenomena such as the wearing of mechanical parts, hardening and cracking of polymers, corrosion of metals and so on. The equipment must be given particular attention during design and manufacture (in particular the choice of materials) and be the subject of a surveillance and preventive maintenance programme, with repair or replacement as necessary. It must also be possible to demonstrate the feasibility of possible replacement.

Equipment or component obsolescence
Equipment that is important for safety is "qualified" for installation in NPPs. The availability of spares for this equipment is heavily dependent on industrial production by the suppliers. Should the manufacturer cease to make certain components, or simply go out of business, this could create original part procurement problems for certain systems. The safety level of any new spares must then be demonstrated prior to installation. This is to ensure that the equipment remains "qualified" with the new spare part. Given the length of this procedure, the licensees must adopt a vigorous forward-looking policy in this area.

The ability of the NPP to follow changes in safety requirements
Greater knowledge and technological improvements, as well as changes in the acceptability of risk in our societies, 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 - closure at some time in the relatively near future.

2|3|3 How EDF manages equipment ageing

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

Including ageing in the design
During 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
During operation, deterioration phenomena other than those designed-in can be revealed. The periodic surveillance and preventive maintenance programmes, the conformity reviews (see point 2|2|1) or the operating experience feedback review (see point 2|2|2) aim to detect 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's policy

From a strictly regulatory standpoint, in France there is no limit on the time that a NPP is authorised to operate. However, Article 29 of the TSN Act requires (III) that the licensee conduct a safety review of its NPP every ten years. The primary aim of this review is to ensure that the NPP's safety level is further improved, but it is also an opportunity to conduct an extensive examination of the effects of ageing on the equipment (see point 2|2|3).

In preparation for the 900 MWe reactors third ten-yearly outages, 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 response to this request, EDF drew up a programme of work concerning management of the ageing of its 900 MWe reactors. After consulting the GPR on two occasions, ASN asked EDF to make a number of additions to this programme, in particular with regard to the large-scale R&D resources available.

The 900 MWe nuclear reactors are the oldest French reactors still in service. Their third periodic safety review is now under way. The GPR met on 20 November 2008 to examine the adequacy of the modifications EDF intends to make in order to improve the safety of its NPPs. ASN will adopt a stance on the action to be taken subsequent to this review.

The third ten-yearly outages will take place as of spring 2009. During the course of these outages, which will last several months, the reactor will be shut down and in-depth, extensive checks will be carried out. Based on the results of these checks and on the changes made following the safety review, ASN will adopt a stance, reactor by reactor, on their ability to continue to operate beyond the third ten-yearly outage and for a period of from thirty to forty years (see sheet no. 2). As necessary, it could request intermediate checks before the forty year deadline.

More generally and in the European energy context, France ideally needs sufficient electricity supply capacity to enable the Government, should the situation so demand, to make a calm and pressure-free decision to shut down reactors for which the safety level is no longer considered to be acceptable by ASN. A decision such as this could for example be made during the safety review mentioned above. It is therefore important that adequate preparation be made for renewal of the means of electricity generation, whatever the method of generation adopted, so that a situation never arises in which nuclear safety requirements conflict with the pressures of energy supply.

2|4 The EPR reactor

After a period of about ten years during which no nuclear reactors were built in France, EDF in May 2006 submitted an application to the ministers responsible for nuclear safety and radiation protection for the creation of a 1600 MWe EPR type reactor on the Flamanville NPP, which already houses two 1300 MWe reactors.

The EPR reactor developed by AREVA, is a pressurised water reactor based on an "evolutionary" design, by comparison with the reactors currently in service in France, enabling it to comply with stricter safety objectives.

The Government authorised its creation by decree 2007-534 of 10 April 2007, following ASN's favourable opinion after the technical review conducted with the assistance of its technical support organisations.

After issue of the authorisation decree (DAC) and the building permit, construction work began on the FA3 reactor in September 2007 and is scheduled to last about 5 years. Pouring of concrete for the buildings on the nuclear island began in December 2007. Since then, rebar installation and concreting work has continued. While the construction activities are proceeding on the Flamanville NPP, the pressure vessels, mainly those making up the primary systems (vessel, pumps, piping, etc.) and secondary systems (steam generators, piping, etc.) are being produced in the manufacturer workshops (see sheet no. 5).

2|4|1 The steps up to commissioning

EDF intends to submit a commissioning application for its NPP in 2010, for an initial fuel load in the reactor at the end of 2011 and operation at nominal power by mid-2012.

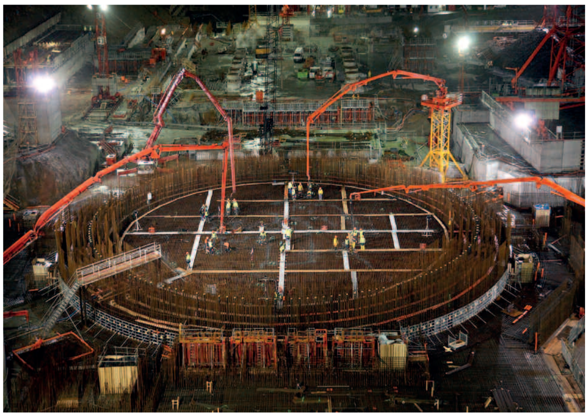
Pursuant to decree 2007-1557 of 2 November 2007 (see point 2|1|4 of chapter 3), ASN authorisation is required for bringing nuclear fuel inside the perimeter of the NPP and starting up the NPP. According to Article 20 of this same decree, the licensee must, one year before the intended commissioning date, send ASN a file comprising the safety analysis report, the general operating rules, a study of NPP waste management, the on-site emergency plan and the NPP decommissioning plan.

Without waiting for transmission of the complete commissioning application file, ASN and IRSN together initiated an advance review of certain topics that required lengthy investigation.

At the same time as this advance technical review, to prepare for the commissioning authorisation, ASN also checks the NPP in order to rule on the quality of NPP construction and its ability to comply with the defined requirements.

Advance review of required documents
The advance review conducted by ASN and IRSN mainly concerns the content of the safety analysis report and the general operating rules which have changed with respect to current reactors, especially concerning:

EPR construction site in Flamanville (Manche *département*) – August 2007: site preparation works



EPR construction site in Flamanville (Manche *département*) – December 2007: pouring of nuclear island foundation raft

– the methodologies and computer software used by EDF to model incident and accident transients that could occur within the reactor;
– the principles and methods for drafting general operating rules within the framework defined by the regulations;
– the organisation of the reactor operations team, for which ASN wishes to request the opinion of the GPR by 2010.

Construction oversight

For ASN there are many construction oversight issues involved for the FA3 reactor. They concern:
– incorporating construction oversight into the new regulatory framework set by the TSN Act;
– controlling the quality of performance of the NPP construction activities in a manner proportionate to the safety, radiation protection and environmental protection issues;
– building on the experience acquired by each party concerned during the construction of this new reactor.

To do this, ASN carries out its regulation and inspection duties and, for the DAC application, produced requirements for the design and construction of FA3 and for the operation of the two Flamanville 1 and 2 reactors located close to the construction site.

The principles and procedures for regulation of EPR reactor construction were approved by the ASN Commission in November 2007. Pursuant to these principles, a reactor construction phase involves the following steps:
– detailed design, during which the engineering studies define the data necessary for construction;
– the construction activities, which include site preparation after issue of the authorisation decree, manufacture, construction, qualification and erection of structures, systems and components, either on the NPP or on the manufacturers' premises.

This oversight also covers control of the risks the construction activities present for neighbouring BNIs (Flamanville 1 and 2 reactors) and for the environment. As we are also dealing with a nuclear power reactor, ASN is responsible for conventional safety inspection duties on the construction site.

2 | 4 | 2 Construction oversight in 2008

Detailed design review

The detailed design review, involving a documentary review and conducted primarily by IRSN, has not yet brought to light any major problems with implementation of the regulatory or safety requirements, with the exception of nuclear pressure vessels, as a result of the entry into force of new regulations in 2006.

To ensure that a rigorous attitude is maintained at all stages in the project, ASN attaches great importance to the quality of the documents supplied by the manufacturer or by the licensee, as well as to the quality of the technical exchanges between IRSN and the manufacturer or licensee. For technical subjects with high safety stakes, such as the design of the I&C system, ASN requested the opinion of the GPR for mid-2009.

In addition to the technical review of the detailed design studies, carried out with the help of IRSN, ASN in 2008 conducted four inspections in the engineering departments in charge of producing these studies and of overseeing manufacturing at the suppliers. ASN for instance checked the implementation of the requirements of the order of 10 August 1984 in the project management system, particularly the requirements concerning contractor management and monitoring, management of deviations and management of operating experience feedback, along with the importance given to safety. Implementation of these requirements was checked both in the engineering departments and on the Flamanville construction site.

During these inspections, ASN observed problems with implementing the detailed design documentary requirements on the construction site, as well as a lack of rigorousness in the exchanges between the departments in charge of the design studies and the construction site. ASN considers that while safety is indeed taken into account by project management and the construction activities, EDF still needs to improve the safety culture[2] of the

2. The "safety culture" as defined by IAEA, is that assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, nuclear safety issues receive the attention warranted by their significance.

EPR construction site in Flamanville (Manche *département*) – March 2008: in-situ assembly of the reactor containment internal metal liner

EPR construction site in Flamanville (Manche *département*) – September 2008: construction of the reactor building with its internal metal liner

various participants and ensure that priority is given to safety over the other project constraints. ASN also considers that improvements could be made in the way the requirements of the order of 10 August 1984 are implemented.

Oversight of construction activities on the FA3 NPP

In 2008, ASN carried out fourteen inspections on the construction site, with the assistance of IRSN. These in particular concerned the following technical topics:
- civil works;
- assembly of the reactor containment's inner metal liner;
- the impact of the construction site on the safety of the Flamanville 1 and 2 reactors.

Following the inspections carried out in 2008 and review of the deviations, ASN considers that apart from the problems with implementing the documentary requirements on the construction site and the requirements of the order of 10 August 1984, EDF must also improve the safety culture of the various parties working on the NPP (contractors and subcontractors).

With regard to ensuring that the risks the construction site presents for the neighbouring reactors in operation are kept under control, ASN and IRSN jointly conducted a review of the risk analysis for the safety of the two neighbouring reactors, ahead of each construction phase. In 2008, the following risks were reviewed by ASN and IRSN:
- construction of the inter-units gallery between the future FA3 NPP and the Flamanville 1 and 2 NPP. Following the analysis conducted by IRSN, ASN asked for specific measures to be taken to protect the power supply cable for the Flamanville 2 NPP, which was situated over the gallery excavation work;
- the risk of mobile cranes falling (currently under review).

EDF presented measures for keeping the risks created by the construction site for the neighbouring installations under control. They were then incorporated in the specific requirements implementing the DAC and subsequently notified to EDF.

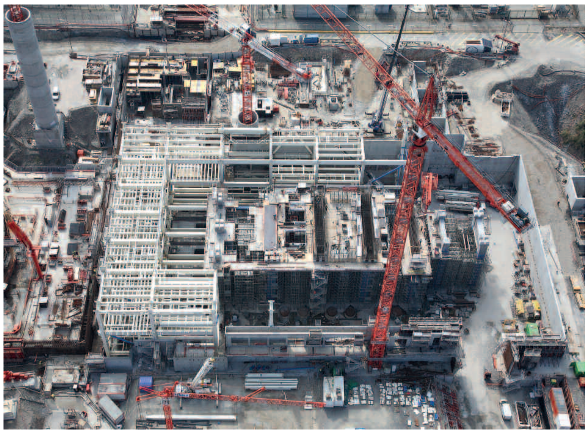
Together with IRSN, ASN also initiated a detailed review of the causes and handling of the deviations most significant for safety. In 2008, the following events, mainly relating to civil works and nuclear pressure vessels, were dealt with:
- appearance of cracks following pouring of a concrete block making up the nuclear island basemat for the FA3 EPR. This cracking phenomenon, resulting from shrinkage of concrete as it hardens, is frequent during large-scale concreting operations. EDF dealt with this problem and worked on improving the concreting conditions to prevent it happening again. On the recommendation of IRSN, ASN considered that the solutions proposed by EDF were acceptable;
- anomalies in the layout of certain reinforcement bars in relation to the construction drawings. During the inspection of 5 March 2008, ASN and IRSN observed anomalies in the reinforcement of the basemat of the building intended for spent fuel storage. For ASN, this situation revealed inadequacies both in the technical surveillance by the group of contractors responsible for civil works and in EDF monitoring of its contractors. Following this observation, EDF took corrective measures to prevent this type of problem happening again. The discrepancies in the spent fuel storage building basemat reinforcements were corrected prior to concreting;
- anomaly in the reinforcement of a part of the basemat of the reactor safeguard systems building. Following EDF notification of this anomaly by ASN in May 2008, ASN considered that the repeated anomalies in the reinforcement or concreting work, albeit with no safety consequences, were indicative of a lack of licensee stringency

with regard to the construction activities on the NPP, problems with monitoring of the contractors and organisational shortcomings. ASN considered that the conditions in which the concreting work was performed on the NPP were unable to guarantee control of the quality required for an NPP. Consequently, on 26 May 2008, ASN asked EDF to suspend concreting operations on the structures important for safety, to analyse the problems observed and to take the necessary corrective measures. More particularly, ASN asked EDF to improve the stringency of the technical surveillance by its contractors and of the monitoring carried out on its own contractors. After a 23-day shutdown and on the basis of the action plan set up by EDF, ASN authorised the resumption of concreting activities on the structures important for safety;

- use of a welding method not authorised in the EDF documentary requirements. During the inspection of 5 June 2008 on the FA3 construction site, ASN and IRSN observed that the welding method used on the plates of the reactor containment internal metal liner was not in conformity with the requirements of the construction code adopted by EDF. At the request of ASN and on the basis of the IRSN appraisal, EDF proposed and carried out additional checks in order to guarantee weld quality;
- anomalies in compliance with the procedures for production of castings subcontracted by the manufacturer AREVA NP: ASN observed deviations during the inspection at the Italian company Società delle Fucine, one of the subcontractors of AREVA NP, responsible for manufacture of certain steel parts of the pressuriser. This anomaly, which consisted in using test equipment that did not comply with the standards, concerns non-compliance with the manufacturing procedures for castings subcontracted by the manufacturer AREVA NP and involves incorrect use of the applicable documentation for the performance of mechanical tests to check the quality of the parts manufactured. For ASN, this anomaly demonstrates shortcomings in the subcontractor's quality system.

The regulations stipulate that the manufacturer, AREVA NP, is responsible for part conformity, including when it subcontracts part of the manufacturing process: AREVA NP is therefore required to implement an appropriate quality system and ensure effective monitoring along the length of the subcontracting chain, so as to control the level of confidence given to the operations performed. ASN observed that the monitoring carried out by AREVA NP was unable to detect the failure of its subcontractor to comply with the procedures.

Consequently, on 24 October 2008, ASN asked AREVA NP to demonstrate the conformity of the parts produced. More generally, ASN considers that AREVA NP needs to tighten up its subcontractor monitoring.



EPR construction site in Flamanville (Manche *département*) – September 2008: construction of the turbine hall

ASN considers that these anomalies indicate inadequate implementation of the requirements of the order of 10 August 1984 and a lack of a safety culture among the various project participants. In the light of these significant events in 2008, albeit with no proven consequences for the level of safety of the future NPP, ASN wishes to maintain stringent and rigorous execution at each step in the construction of the FA3 reactor.

Regulation of nuclear pressure vessel manufacture

Either itself or through authorised organisations, ASN performed fifty inspections in 2008 at the manufacturer AREVA NP, its suppliers and their subcontractors.

During these inspections, ASN detected numerous discrepancies indicating a lack of stringency in the performance and supervision of the manufacturing activities. The main problems arise from the fact that equipment manufacture started before the detail design was finalised. ASN considers that these anomalies are indicative of inadequate compliance with the requirements of the nuclear pressure vessels order and the order of 10 August 1984 and of a lack of safety culture.

EPR construction site in Flamanville (Manche *département*) – September 2008: construction of the pumping station

Decision 2008-DC-0114 of 26 September 2008 stipulating requirements for EDF concerning the Flamanville NPP site with regard to the design and construction of the FA3 reactor and the operation of the Flamanville 1 and 2 reactors

Pursuant to the TSN Act, ASN laid down design and construction provisions for the FA3 reactor in its decision 2008-DC-0114 of 26 September 2008 published in the ASN Official Bulletin on the authority's website.

This first series of 58 provisions:

- *sets the technical requirements concerning the detailed design of the NPP. These requirements were based on IRSN's technical instructions and the GPR's opinions, on which ASN in turn based its opinion on the FA3 draft authorisation decree;*
- *defines the conditions for the construction of the NPP in terms of the information to be transmitted to ASN and the steps to be taken to ensure that the impact of the construction work on the two neighbouring reactors in operation on the NPP is kept under control. These requirements were drafted on the basis of the operating experience feedback from the ASN controls carried out on the NPP.*

ASN will ensure that these provisions change throughout the lifecycle of the NPP. ASN in particular intends to issue additional requirements to deal with the reactor commissioning and operating conditions, especially with regard to effluent discharge and water intake procedures and limits.

Pursuant to the TSN Act provisions, ASN will check that EDF complies with these requirements. Should it fail to comply with a requirement, ASN would send EDF formal notice and then, should this be ignored, would apply administrative sanctions (fine, imposed performance of the work, suspension of NPP operation).

Conventional safety inspection on the FA3 reactor construction site

The conventional safety inspection on the FA3 construction site was carried out by the Manche *département* Labour, Employment and Professional Training Directorate (DDTEFP) and covered the preparatory work phases up to signing of the authorisation decree. Since 10 April 2007, conventional safety inspection has been the responsibility of ASN's Caen division. The action taken in 2008 consisted in:

- participation in meetings of the joint companies commission for safety, health and working conditions (CIESSCT) and the operational committee for the prevention of illegal labour (COLTI);
- performance of safety inspections on the NPP;
- performance of investigation of accidents occurring on the NPP;
- response to direct queries from the employees;
- response to requests concerning risk prevention plans on construction sites with a large number of contractors working alongside each other.

In 2008, ASN's conventional safety inspectors in particular checked compliance with the provisions of the Labour Code by the companies working on the NPP, with regard to labour contracts and declaration of workers, pay, company financial guarantees and employee contributions and social security protection.

In 2009, faced with the scheduled activity peaks on the FA3 NPP and the risks inherent in multi-contractor civil and systems erection work, ASN intends to reinforce its regulation of the prevention of occupational accident risks.

2 | 4 | 3 Cooperation with foreign nuclear regulators

At a time when nuclear programmes are enjoying renewed interest worldwide and in order to share experience with other regulators, ASN is increasing its technical exchanges with its foreign counterparts on the design and construction of new reactors.

Rising demand for bilateral cooperation

This year ASN responded to a rising number of requests to share experience of safety requirements for new reactors and licensing procedures for new NPPs. In 2008, ASN and IRSN took part in bilateral meetings with the nuclear regulators of China, Finland and the United Kingdom.

In 2008, ASN took part in a three-day seminar organised by the Chinese nuclear regulator in Beijing, during which it presented the work done by ASN and its technical support organisation since the EPR project was launched in 1993.

Owing to the EPR reactor construction projects at Olkiluoto in Finland and Flamanville in France, ASN and IRSN in 2004 set up enhanced cooperation with the Finnish nuclear regulator (STUK). In 2008, this enhanced cooperation led to a meeting to discuss inspection practices, the deviations observed and civil works matters. During this meeting, held in France at the ASN Caen Division, the Finnish inspectors took part in an inspection on the FA3 construction site, as observers.

Enhanced bilateral cooperation with the United Kingdom takes the form of secondment of a British inspector to the ASN for several years and technical exchange meetings, particularly concerning I&C.

Towards multinational cooperation

In 2007, the US Nuclear Regulatory Commission (NRC) received an application for certification of an EPR reactor from an industrial group. Cooperation between France and Finland was therefore extended to the United States, for drafting of a multinational cooperative programme for new reactors, called MDEP (Multinational Design Evaluation Program). Canada and the United Kingdom are now also participants in the MDEP group dedicated to the EPR reactor. Three EPR reactor meetings were held in January, June and November 2008, one of which focused on the topic of I&C.

Other international structures, such as the NEA, also offer opportunities to discuss practices and lessons learned from regulating reactor construction, over and above simply the EPR. ASN therefore took part in the Working Group on Inspection Practices (WGIP) which in 2008 looked at regulating the construction of new NPPs, among other topics. For ASN, these international exchanges are one of the driving forces behind the harmonisation of safety requirements and regulatory practices.

2 | 5 Future reactors: generation IV

The research organisations and industrial firms of twelve leading nuclear countries, along with the European Union through EURATOM, are preparing for the fourth generation of reactors within the "Generation IV International Forum" (GIF) launched in 2000. Within the GIF, these various partners are pooling their research and development (R&D) efforts in order to assess the potential of different possible reactor technologies.

As part of this international cooperation, the French industrial firms (CEA, AREVA, EDF) are more particularly committed to R&D programmes on sodium-cooled fast neutron reactors (RNR-Na) – a technology for which France already has considerable expertise with Phénix and Superphenix – but also on gas-cooled fast neutron reactors – which is a more long-term prospect requiring further technological innovation.

In the planning Act of June 2006, France set itself the goal of commissioning a first industrial prototype of a fourth-generation reactor by 2020, to pave the way for possible industrial deployment in about 2040-2050.

With this medium to long-term project in mind, ASN plans to initiate monitoring of the development by the industrial partners of the fourth generation of reactors and the corresponding safety prospects. In 2008, these partners therefore presented their specific RNR-Na safety research programme to ASN and IRSN at a seminar.

Although safety improvements can be legitimately expected from the generation IV reactors, by comparison with today's reactors, ASN however considers that it would be premature to attempt at present to set the safety objectives to be met by these new reactors which would only come on-stream in a few decades. For that reason, to be able, when the time comes, to define the safety objectives to be achieved by these future industrial reactors, ASN launched a joint working group with IRSN in 2008. This group is to look at the areas of R&D concerning the safety of these new reactors, as well as the reasons that led the designers to adopt these rather than other areas.

Although the initial work done on this subject concerns the safety prospects of the RNR-Na technology promoted by CEA for its industrial prototype project, ASN also wishes to examine the safety of other technologies, together with IRSN, in order to ensure that at this stage the debate on the safety objectives of the next generation of industrial reactors is kept open.

2 | 6 Research into 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 processes for operation and maintenance; these solutions replace techniques or intervention methods which offer a lesser degree of protection;
– certain research work aims to improve knowledge of the risks, in order to better target protective measures or even spotlight risks that had hitherto been poorly assessed: this is for example the case with experiments concerning the phenomenon of sump clogging, or studies into individual and group behaviour in stressful situations, leading to an improved evaluation of the role of human and organisational factors;

– 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.

Research into nuclear safety and radiation protection frequently requires the modelling of complex systems (NPPs, the physical-chemical phenomena involved, etc.): the development of increasingly sophisticated computer codes using constantly growing and changing IT resources must be mastered, from expression of requirements to validation of the tool. ASN is attentive to this validation phase, so that the demonstrations by the licensee or the appraisals by the technical support organisations are based on scientifically proven methods or results.

Knowledge of the latest research findings and those questions which still remain unanswered enable the regulatory authorities to measure how realistic their demands really are. ASN therefore keeps abreast of ongoing research work to ensure that its demands are pertinent. The ability of the regulatory authorities, or their advisory expert organisations, to control the direction in which research is going, enables them to look again at safety issues that were assumed to be resolved: for example, interpretation of the experiments conducted by IRSN led to a review of the sump clogging risk.

Furthermore, if this knowledge of the latest research findings is important during international discussions between safety regulators, when comparing our nuclear safety and radiation protection actions, then it is essential to the ASN and IRSN contribution to the drafting of recommendations for the IAEA guides.

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 NPPs even safer. ASN therefore asked EDF to send it its annual budgets and workforce numbers allocated to research, with a view to monitoring trends. ASN's findings show that EDF's budget in this field is at present at a high level, even if there has been a slight downward trend for a few years. It also observes with satisfaction that there are still a number of driving forces behind research into nuclear safety and radiation protection, whether technological or in terms of human and organisational factors:

– new reactor projects: the research work initiated for the EPR reactor led to the development of new solutions, some of which could be implemented on the existing reactors;
– the desire of industry to improve the performance of its tools: for example, EDF's intention to increase nuclear fuel performance in particular generated work on uranium oxide ceramics, fuel assembly cladding materials and the design codes. This work is also a means of advancing the store of available knowledge and, in certain cases, enhancing safety, for example by improving accident study methods;
– 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 event experience feedback; for example the research into the risk of flooding or modelling of oil slick drift.

3 NPP SAFETY

3 | 1 Operation and control

3 | 1 | 1 Normal operating conditions

Technical operating specifications (STEs)

Chapter III of the GORs presents the technical operating specifications (STEs) for the reactor, the role of which is:

– to define the normal operating limits of the NPP if it is to remain in conformity with the reactor design basis scenarios;
– depending on the condition 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 required to modify the STEs to take account of its operating experience feedback, improve the safety of its NPPs, improve economic performance or even incorporate the consequences of equipment modifications.

In 2008, ASN reviewed a number of documents modifying the STEs permanently, which were either approved or were the subject of requests for additional justifications. Two files concern equipment modifications to be implemented during the third ten-yearly outages of the

CPY reactors and the second ten-yearly outages of the 1300 MWe reactors.

Temporary STE modifications

When, in exceptional circumstances, EDF needs to deviate from the normal operation required by the STEs during an operating or maintenance phase, it must notify ASN of a temporary modification of the STEs. ASN reviews this modification and may approve it, possibly subject to implementation of remedial measures if it considers that those proposed by the licensee are insufficient.

ASN ensures that the temporary modifications are justified and conducts an in-depth yearly review on the basis of a summary produced by EDF. EDF is therefore required:

- periodically to re-examine the reasons for the temporary modifications in order to identify those which would justify a request for permanent modification of the STEs;
- to identify generic modifications, in particular those linked to implementation of national equipment modifications and periodic tests.

118 temporary STE modifications were reviewed in 2008, including 17 that were generic.

Field inspection of normal operation

During NPP reviews, ASN checks:

- compliance with the STEs and, as necessary, with the remedial measures associated with the temporary modifications;
- the quality of the normal operating documents, such as the operating instructions and alarm sheets, and their consistency with the STEs;
- staff training in reactor operations.

3 | 1 | 2 Incident or accident operations

The condition-based approach (APE)

In the event of an incident or accident on the reactor, the personnel have operating documents at their disposal, designed to enable them to return the reactor to and maintain it in a stable condition.

The steps to be taken in the event of an incident or accident use the condition-based approach (APE). The APE consists in defining operating strategies according to the identified physical condition of the nuclear steam supply system, regardless of the events that led to this condition. Should the condition deteriorate, a permanent diagnosis enables the procedure or sequence in progress to be aborted and a more appropriate procedure or sequence to be applied.

These operating documents are drafted on the basis of incident and accident operating rules, as presented in chapter VI of the GORs. Implementation or modification of these documents must be notified to ASN. During 2008, ASN continued to review the changes to the operating rules for the nuclear reactors in operation, proposed by EDF and in particular approved implementation of:

- the files dealing with simplification of use of the water level in the vessel for each of the nuclear reactor series;
- the files relating to the ten-yearly outages (VDs) for each of the nuclear reactor series. Some modifications to the APE procedures are the result of hardware modifications to be incorporated during the VDs, while others are the result of operating experience feedback or a response to ASN requests for improved safety.

Following on from the “incident or accident response procedure” project (CIA), ASN in 2008 reviewed the work concerning processing of partial power-outs for the CPY reactors.

Finally, ASN and its technical support organisation worked together with EDF on rewriting chapter VI of the GORs. This work led to harmonisation of the various GOR chapters and uniformity between chapter VI of the GORs in use in the various NPPs.

Regular inspections are organised on the subject of incident and accident operation. These inspections in particular review the management of the chapter VI operating 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. On the basis of the inspections conducted in 2008, ASN feels that adoption by NPPs of the incident or accident operations rules is on the whole satisfactory.

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 deterioration, 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 action guide (GIAG). In 2006, EDF completed transcription of the GIAG into operator documents for all reactors. The documents produced are intended for use by the control teams, staff on duty in the NPP and by the local and national emergency teams.

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

On 27 November 2008 the GPR reviewed the progress of the work devoted to severe accidents, particularly the EDF severe accidents reference documentation, the operating options concerning water injection, the use of the discharges filtration system and the risk of sump clogging.

In July 2008 in Paris, ASN also took part in exchanges with IAEA on the subject of the draft severe accidents management guide.

3|2 Maintenance and testing

3|2|1 Maintenance practices

Since the mid-1990s, EDF has been implementing a policy to reduce the volume of maintenance work. Its aim is to enhance the competitiveness of the nuclear reactors in service, while maintaining the level of safety. This chiefly involves focusing the maintenance effort on equipment which, if it were to fail, would entail the highest safety, radiation protection or operational risks. This policy has led EDF to adapt its organisation and adopt new maintenance methods (reliability-centred maintenance, condition-based maintenance and maintenance using pilot equipment).

As is already the case in the aeronautical and military industries, EDF has developed the "reliability-centred maintenance" method. Based on a functional analysis of a given system, this method enables the type of maintenance required to be defined according to the contribution of its potential failure modes to the safety, radiation protection or operational stakes.

Furthermore, taking advantage of nuclear reactor standardisation, EDF is deploying the "pilot equipment" concept. This maintenance is based on the definition of uniform technical families of similar equipment, operated in the same way in all the NPPs in operation. EDF considers that the selection and close monitoring of a limited number of these equipment items - which then act as pilot items within these families - could, if no failure is detected, spare systematic monitoring of all the equipment in the family.

In this context of widely changing methods and in the light of nuclear reactor ageing, ASN asked the GPR for its opinion on EDF's maintenance policy and its implementation on NPPs. The GPR held a meeting on this subject on 27 March 2008.

Based on this review, ASN's opinion of the EDF maintenance policy is on the whole positive. More particularly, ASN considers that the methods used by EDF to optimise the maintenance programmes for the equipment important for safety are acceptable. These methods, which give priority to equipment monitoring, help to reduce the risks involved in equipment maintenance and limit the dose received by the staff involved. ASN did however remind EDF that these methods could lead to failure to detect a new fault or one that was not initially envisaged and asked EDF, as part of the defence in depth principle, to back up the deployment of these methods by maintaining systematic periodic checks for certain equipment.

ASN also reminded EDF that the use of these maintenance methods for the pressure vessels on the main primary and secondary systems of nuclear reactors must comply with the requirements of the order of 10 November 1999 concerning the supervision of the operation of these systems (see point 2|2|1, table 2 of chapter 3).

ASN also considers that the process set up by EDF for building on operating experience feedback is a means of ensuring satisfactory development of the maintenance programmes. ASN will ensure that EDF takes account of operating experience feedback about the behaviour of the equipment concerned by these changes, in particular with regard to the content and frequency of the inspections.

3|2|2 Qualification of scientific applications

The scientific applications contributing to the safety cases are subject to the requirements of the order of 10 August 1984 mentioned in point 2|2|1 of chapter 3. One of the key requirements is qualification, which consists in ensuring that the application can be used in complete confidence within a specific field.

In 2008, ASN continued to review applications which will be used for EPR reactor studies.

Furthermore, ASN is continuing its work aimed at defining the principles and methods to be used for the qualification review of the computer codes used in the safety case demonstrations.

Finally, following the discovery of an anomaly in a computer code used for certain accident studies supplied by AREVA, ASN carried out an inspection in 2008 on the organisation of the procedures used by EDF and AREVA to guarantee software and study development quality. Further to this inspection, ASN asked EDF to re-examine the anomaly handling process implemented by its supplier, to make the necessary modifications and to amend its own documents on this subject.

3 | 2 | 3 Qualification of inspections methods

Article 8 of the order of 10 November 1999 specifies that the non-destructive test processes used for in-service monitoring of nuclear reactor main primary and secondary systems must, before they are used, undergo qualification by an entity chosen by the licensee, of proven competence and independence.

This entity, called the qualification commission, received accreditation by the French accreditation committee (COFRAC) in 2002, followed by renewal in 2006.

The role of this commission is to assess the representativeness both of the mock-ups used for the demonstration and the faults introduced into them. On the basis of the qualification results, it confirms that the performance of the examination method is as expected. A description of the qualification process was also codified in the in-service monitoring rules for the mechanical equipment of PWR nuclear islands. As applicable, the aim is either to demonstrate that the inspection technique used allows detection of deterioration as described in the 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 granted transitional periods of varying lengths for implementation of their respective programmes.

Ultrasonic inspection of a weld joint

To date, seventy-nine applications have been qualified by the in-service inspection programmes.

New applications are currently under development and qualification to address new requirements, especially concerning the FA3 reactor, for which forty-two applications must be qualified for the pre-service full inspection scheduled for the summer of 2010.

3 | 2 | 4 Periodic tests

In order to check the correct operation of equipment important for safety and the availability of the back-up systems that would be called on in the event of an accident, tests are periodically conducted in accordance with the programmes of chapter IX of the GORs.

In 2008, ASN continued a review of the periodic test programmes and approved the following:
– the changes to the periodic test programmes for the technical and documentary package "PTD Lot 93-2001" for the 1300 MWe reactors;
– the periodic test programmes linked to the hardware modifications to be incorporated during the third ten-yearly outages of the 900 MWe reactors;
– the test programmes linked to the hardware modifications to be performed for the first ten-yearly outage of the N4 "first off" reactor.

ASN also initiated a review of the design policy for the EPR periodic tests.

At the same time, ASN is regularly called on to give its opinion on periodic test programme modification notifications.

3 | 3 Fuel

3 | 3 | 1 Fuel management trends

In order to enhance the availability and performance of reactors in operation, EDF, together with the nuclear fuel industry, is looking for and developing improvements to fuels and their use in the reactor, known as "fuel management".

Since 1996, extending cycle lengths has been a major factor in optimising reactor fuel and operations. This extension is combined with increased fuel enrichment, but the quantity of energy released nonetheless remains limited to an average of 52 GWd/t per fuel assembly, which is the maximum authorised value. ASN ensures that each new fuel management model is the subject of a specific safety case for the reactors concerned, based on the specific characteristics of the new fuel management. When a change in the fuel or its management model leads to EDF revising an accident study method, this requires prior review and cannot be implemented without ASN approval. Since 2007, the adoption of new fuel management requires a decision from ASN containing implementation requirements.

MOX-parity

MOX-parity fuel management concerns the twenty-two 900 MWe reactors authorised to recycle plutonium. It is characterised by:
– increased burn-up fraction of the MOX fuel assemblies as a result of the greater number of operating cycles (four cycles in the reactor instead of three);
– changes to the initial plutonium content (average of 8.65% instead of 7.1%).

This management is a means of keeping the quantities of plutonium generated by the French NPPs under control.

As at 31 December 2008, seven reactors had implemented MOX-parity management.

GALICE

As of 2009, EDF envisages replacing the existing management, operational on the twenty 1300 MWe reactors, with GALICE management. The uranium 235 enrichment of the fuel assemblies would rise from 4% to 4.5%. The maximum fuel burn-up fraction would then be 62 GWd/t and refuelling would be hybrid: some assemblies would undergo three cycles and others four. The average cycle duration would still be 18 months but, after review of an additional file by ASN, this could vary from 15 to 21 months, in order to offer flexibility when scheduling refuelling outages.

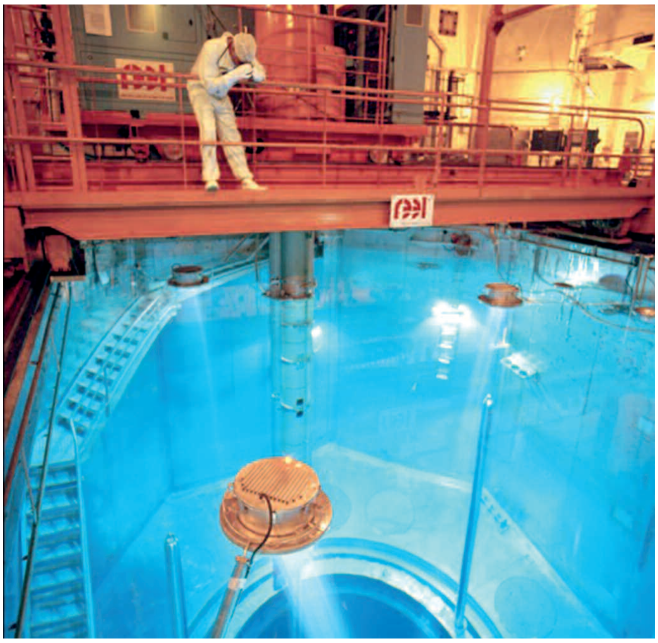
In 2008, ASN continued its technical review of this fuel management and asked the GPR for its opinion, particularly with regard to fuel behaviour at high burn-up fractions and the design of the protection and safeguard systems. Following the GPR meeting of 12 June 2008, ASN asked EDF for additional information before it could adopt a stance and issue requirements relative to this management.

3 | 3 | 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 component material and shape of the metal parts of the assembly (cladding, skeleton assembly, end-pieces, etc.) and the fuel pellet material.

M5 alloy fuel assemblies

Since 2005, ASN has authorised the irradiation of AFA3GlrAA fuel assemblies (M5 alloy cladding and



Check on reactor loading on the Blayais site (Gironde *département*)

Blockage of two fuel assemblies during core unloading of the Tricastin 2 reactor

On 8 September 2008, during unloading of the core of the Tricastin 2 reactor, two fuel assemblies remained snagged on the centring pins of the reactor upper internals. Unloading of the fuel assemblies at the end of each reactor operating cycle requires that the vessel be opened and then the upper internals removed.

The operations were interrupted by EDF to prevent any risk of the fuel assemblies falling into the vessel, until an appropriate solution could be found to secure and then recover them.

Following this event, ASN asked EDF to analyse the consequences of the possible falling of the assemblies and to define the steps to be taken to remedy this event. An event of the same type happened in the Nogent-sur-Seine power plant in 1998. At the time, ASN had asked EDF to analyse the causes of this event and take the necessary steps to prevent it happening again. ASN observed that these measures were not sufficient to address the specific aspects of the situation that occurred at Tricastin.

ASN also conducted an unannounced inspection on 17 September 2008 in the Tricastin NPP in order to examine EDF management of the event and the steps taken to mitigate any consequences.

The technical solution proposed by EDF was analysed by IRSN. ASN considered that the planned process was satisfactory. In order to qualify the tool, the work was initially carried out on a full-scale mock-up on 17 October 2008, in the PWR NSSS maintenance techniques experimentation and validation centre in Chalon-sur-Saône. ASN attended these operations and was able to assess the good safety and security conditions associated with the work.

The sequence of operations involved in securing the assemblies, separating and then extracting the upper internals was carried out on the Tricastin NPP on 24 and 25 October 2008 and enabled the two assemblies and the rest of the core to be unloaded satisfactorily.

This event entailed no releases either inside or outside the reactor building containment and the assemblies remained cooled at all times. The event was rated at level 1 on the INES scale. Tricastin reactor 2 was authorised to restart in December 2008.

In an initial analysis transmitted to ASN, EDF explained the blockage of the assemblies by the discovery of a clearance which generated an offset between the pins of the upper internals and the ends of the assemblies. This clearance was presumably caused by foreign bodies located on the lower core plate, causing the two assemblies to tilt.

ASN asked EDF to tighten up its surveillance of foreign matter and to forward an in-depth analysis of this event and the lessons it has learned from it.

structure) for a period of three operating cycles in three 1300 MWe reactors (Cattenom 3, Golfech 2 and Nogent 2) and for a period of four cycles in the four N4 reactors (Chooz B1, Chooz B2, Civaux 1 and Civaux 2).

Acquisition of operating experience feedback and characterisation of tightness defects that appeared on some of these assemblies, led EDF to take steps to improve the welding process for the fuel rods making up the assemblies loaded as of 2007, in order to reduce the incidence of cladding tightness defects. The fuel assemblies loaded in 2008 showed no signs of tightness defects at the welds concerned by these improvements. However leaks detected on the M5 alloy rods in 2008 are currently being characterised by EDF.

ASN asked EDF to limit the introduction of new M5 fuel loads and to send it the results of the investigations being carried out to identify the causes of the faults observed.

3 | 3 | 3 Fuel handling operations

Fuel handling operations, during which end-of-life fuel assemblies are replaced by new assemblies, take place with the reactor shut down and vessel open. Refuelling requires underwater handling of fuel assemblies between the fuel building pond and that in the reactor building, so that they can be positioned in the reactor vessel in accordance with a predetermined plan and pre-defined reloading sequences. The sequences employed on the 1300 MWe reactors underwent modification in 2008, which was reviewed by ASN, in order to reduce the risk of damage to the assemblies during handling.

For the past two years, the organisational improvements made by EDF in the handling shift changeover and the use of cameras to monitor fuel handling, have strengthened the lines of defence against loading errors and made the handling operations more reliable. In 2008, ASN carried out inspections which showed that the technical and organisational arrangements on NPPs were on the whole satisfactory.

In 2008, ASN paid particular attention to handling of fuel assemblies when they were received on NPPs. ASN carried out inspections which revealed shortcomings in the notification and processing of certain significant events affecting the new fuel. After analysing the problems, ASN asked EDF for greater operational stringency and greater transparency when dealing with this type of event.

Finally, ASN asked EDF to analyse the risk of falling by the transport packages of each plant series and to make handling more reliable in order to achieve the best possible level of safety on all NPPs. Review of these changes will continue in 2009.

3 | 4 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 fundamental safety functions - confinement, cooling, and reactivity control - they are the subject of extensive surveillance and maintenance by EDF and in-depth monitoring by ASN. Supervision of the operation of these systems is regulated by the order of 10 November 1999, mentioned in chapter 3, point 2 | 2 | 1 (table 2).

On the whole, ASN feels that the condition of the CPP and CSP in the French nuclear power reactors give no cause for concern in the short term but that the known ageing and deterioration phenomena need to be considered and appropriate measures taken, primarily in preparation for the third ten-yearly outages of the 900 MWe reactors.

However, ASN observed that further deterioration and anomalies were occurring on the steam generators, particularly since 2006 (see point 3 | 4 | 4).

3 | 4 | 1 System monitoring

When designing the main primary and secondary systems, the manufacturer evaluates how the NSSS is likely to be damaged by the transients that it will experience during operation. It then builds-in a sufficient design margin to ensure that the various deterioration modes identified, particularly fatigue-related phenomena, will not compromise the integrity of the NSSS.

In order to ensure that the licensee operating an NPP 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 monitor 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 order of 10 November 1999 thus requires that the licensee gather and update all system design, manufacturing and operating data which contribute to justifying system integrity.

Owing to the uniformity of French nuclear reactors, EDF has chosen to arrange these reference files in "series" for all the reactors in each series (CP0, CPY, P4, P'4 and N4) and to break them down into "reactor" files for each individual reactor. Each "reactor" file in particular contains data concerning maintenance, faults and events that have occurred on this reactor.

Transient bookkeeping

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 keep track in its documentary system of those transients actually experienced by the NSSS main systems. The purpose of transient bookkeeping is to ensure that the safety margins are maintained throughout the life of the reactor.

For CP0 and CPY reactors, the reference files should be updated before the third ten-yearly outages scheduled as of 2009 for the 900 MWe reactors. Incorporating operating experience feedback concerning transient bookkeeping is an important aspect to be considered when demonstrating the ability of these reactors to continue to function beyond thirty years. The transients file was updated in 2008. The corresponding mechanical calculations will continue in 2009. The entire updated reference file will be forwarded by EDF to ASN at the end of 2009.

For P4 and P'4 reactors, the transients file for the 1300 MWe reactors is currently being updated. The notes associated with the main secondary systems will be revised in 2009. The entire updated reference file will be forwarded by EDF to ASN in 2011.

Finally, for N4 reactors, the reference files should also be updated before the first ten-yearly outages scheduled to start in 2009 for the 1450 MWe reactors. The notes of the transients file were revised in 2008 and will be sent to

ASN at the end of 2009, with the entire updated reference file for this plant series.

Surveillance programmes

Pursuant to Article 5 of the order of 10 November 1999, the licensee must check that the surveillance programmes are adequate prior to each complete post-maintenance qualification. The first ten-yearly outages for the 1450 MWe reactors and thirty-year outages for the 900 MWe reactors will take place at the beginning of 2009. In 2008, ASN therefore examined these new programmes that are applicable to the main primary and secondary systems of the 900 MWe and 1450 MWe reactors. The surveillance programmes review ended in November 2008. In accordance with Article 6 of the above-mentioned order, EDF took account of the observations made by ASN in the final programmes to be applied as of 2009.

3 | 4 | 2 The use of nickel-based alloys

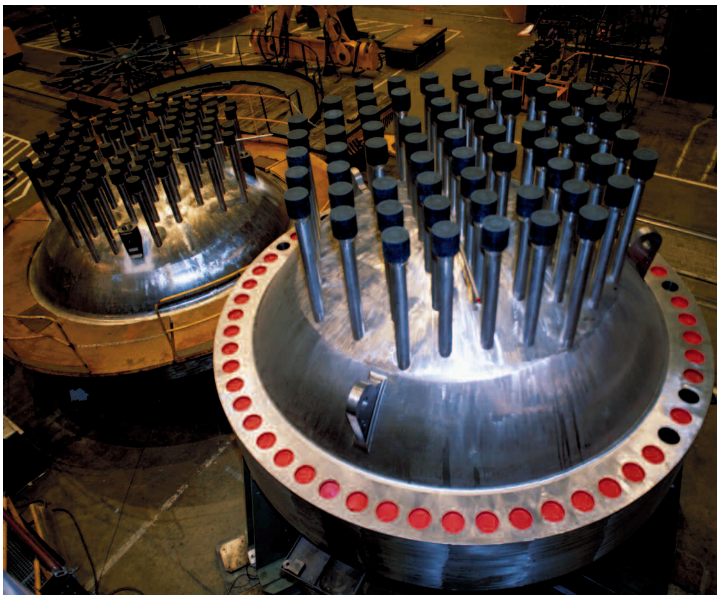
Several parts of a pressurised water reactor are made from nickel-based alloys: tubes, partition plate, primary side coating of the steam generators tubesheet, vessel closure head adapters, vessel bottom head penetrations, vessel internals lower guide support welds, repaired vessel nozzle areas.

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

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

Following the discovery in 2004 of cracks attributed to stress corrosion on a steam generator partition plate (plate separating the hot leg from the cold leg in the lower part of an SG for circulation of primary fluid) which was not in principle considered by EDF to be susceptible to this type of damage, and following international operating experience feedback, ASN asked EDF to adapt its overall maintenance strategy for the Inconel 600 zones, to take account of this type of damage. All the 900 MWe reactor steam generators equipped with an Inconel 600 partition plate will therefore be inspected before their third ten-yearly outage.

The checks carried out in 2007 highlighted stress corrosion cracking indications on some partition plates with a depth greater than the characterisation threshold, that is two millimetres. The checks carried out in 2008 on these partition plates showed no significant change in these indications.



Vessel closure head during manufacture (AREVA)

3 | 4 | 3 Reactor vessels

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

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

In normal operation, the vessel deteriorates slowly, under the effect of the neutrons resulting from the core fission reaction, which embrittles the metal. This embrittlement makes the vessel particularly sensitive to pressurised thermal shocks or to sudden pressure surges when cold. This susceptibility is also aggravated when defects are present, which is the case of some of the 900 MWe reactor vessels, which comprise manufacturing defects under their stainless steel liner.

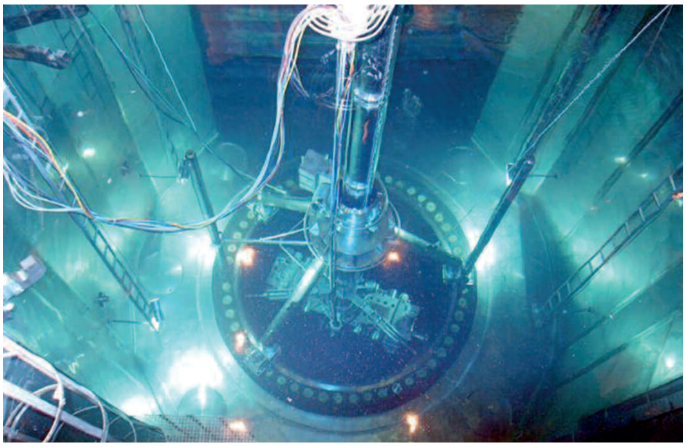
To protect against all risk of rupture, the following measures were taken as of commissioning of the first EDF reactors:
– a program to monitor the effects of irradiation: capsules containing test specimens made of the same metal as the reactor vessel were placed inside the reactor, near the core. Some of these capsules are regularly removed for mechanical testing. The results give a good picture of the ageing of the vessel metal and can even be used to anticipate it, inasmuch as the capsules located near the core receive more neutrons than the metal of the reactor vessel;
– periodic checks, in particular ultrasonic checks to verify that there are no defects or, in the case of vessels containing manufacturing defects, to check that they are not getting worse.

ASN reviewed the files concerning the in-service strength of the reactor vessels forwarded by EDF in preparation for the third ten-yearly outages of the 900 MWe reactors. These files were presented to the experts of the nuclear standing section (SPN) of the Central Committee for Pressure Vessels in 1999 and then in 2005. ASN is today reviewing the answers provided by EDF to the questions raised at this later session. Subsequent to this review and in the light of the results of the inspections made during the third ten-yearly outages on the reactors, ASN will adopt a stance on the conditions for vessel operation beyond thirty years.

3 | 4 | 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 from 3500 to 5600 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 SG tube bundle is a major safety issue, as deterioration of the tube bundle can lead to a leak from the primary system to the secondary system. 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. The SG tubes are subject to a number of deterioration phenomena, such as corrosion and wear.



Vessel in-service inspection machine during an inspection

The SG are covered by a specific in-service monitoring programme, established by EDF and periodically revised. The current version of this programme was reviewed and accepted by ASN in 2003. A new version is currently being reviewed by ASN. Following the checks, those tubes which show excessive levels of damage are plugged to remove them from service.

Since the early 1990s, EDF has been conducting a replacement programme for steam generators with the most heavily damaged tube bundles. This programme will continue at the rate of one reactor a year. At the end of 2008, nine of the thirty-four 900 MWe reactors will still be equipped with steam generators containing Inconel 600 alloy based tube bundles which have not undergone heat treatment (600 MA), these being the main ones affected by stress corrosion cracking (see point 3|4|2).

Steam generator clogging: consequences and treatment

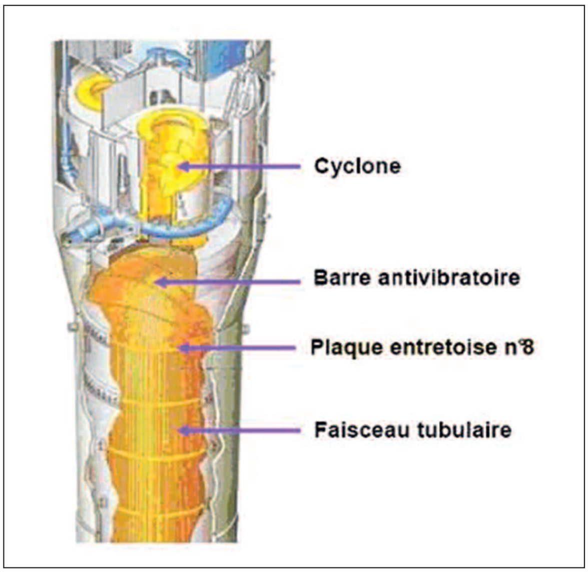
ASN today observes that new damage is beginning to appear in several of the steam generators in operation. The origin of this damage is not always precisely known and although it can be extremely fast, its rate of development is hard to predict. In some cases, it can lead to leaks between the primary and secondary systems, entailing unscheduled reactor shutdown and requiring additional and sometimes extremely lengthy investigations. Moreover, the reactor safety consequences of the treatment methods used may prove hard to manage: for example, problems were encountered during chemical washing, tube plugging or attempted tube extraction.

For instance, a generic steam generator clogging phenomenon was brought to light following a significant event rated at level 1 on the INES scale, which occurred in February 2006 on Cruas-Meysse reactor 4. A crack developed on a steam generator tube in just a few months, leading to a leak. One of the root causes behind this crack was clogging of the upper tube support plates in the steam generator. This clogging phenomenon involves gradual blockage by oxide deposits of the passages between the tubes and the support plates, designed to allow circulation of the water. It can have a number of safety consequences:

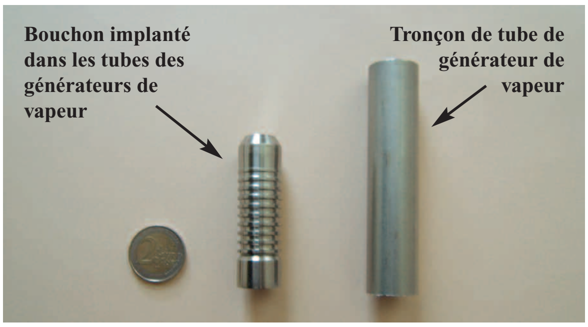
– it is probably the determining factor in the appearance of excessive tube vibration in certain areas of the steam generators, which can lead to the rapid appearance of cracks, as was the case on the Cruas-Meysse reactor 4. EDF thus preventively blocked off a zone of fifty-eight tubes in the steam generators potentially concerned by the phenomenon;
– it can induce considerable mechanical stresses on the steam generator internal structures, particularly in certain incident or accident situations;
– it reduces the water circulation in the steam generators and therefore, for the same measured water level, leads to a reduction in the quantity of water available inside the steam generator. Water level oscillations can also occur in the steam generators in certain operating situations if the clogging levels are high.

Since this event and at the request of ASN, EDF has developed and carried out checks on certain steam generators of the 900 MWe reactors on the occasion of their maintenance and refuelling outages. High clogging levels were observed on a number of reactors, a fact that had not been anticipated by EDF. On the upper tube support plates of some of them, up to 80% of the surface area of the water circulation passages is affected. EDF also estimates that clogging is progressing at a rate of about 5% per year.

As this phenomenon is liable to affect the 1300 MWe reactors, ASN also asked EDF to extend the checks to the steam generators concerned. Although EDF gave initial clogging rate estimates based on the evolution of a number of operating parameters, it has since 2008 had access to additional investigative resources allowing a more precise evaluation of its steam generator clogging rates.



Description of the upper part of a steam generator tube bundle



Installation of equipment during chemical cleaning of a steam generator

The steam generators of all the reactors potentially affected by this phenomenon are therefore inspected during the refuelling outages. If the condition of a reactor does not enable it to be operated in complete safety, EDF must repair it. ASN therefore asked EDF to propose a solution for reducing the clogging levels of the worst affected steam generators.

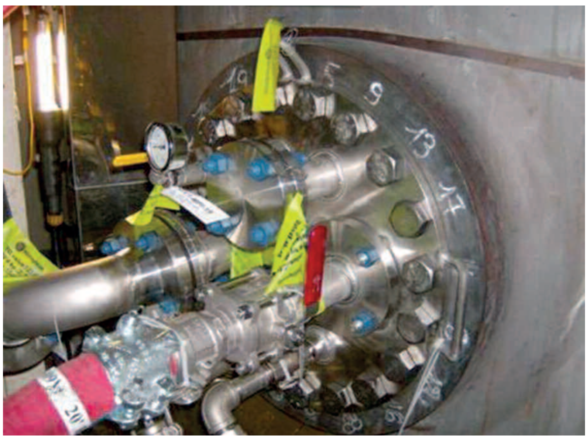
EDF initially opted for chemical washing, which consists in injecting a high-temperature chemical solution into the secondary part of the steam generator during the outage, in order to dissolve the oxide deposits.

Owing to its environmental effects (ammonia releases in particular) and its potential impact on the equipment (corrosion of certain parts of the steam generator), this intervention must be examined beforehand by ASN whenever it is to be used.

The washing process was used for the first time in April 2007 on Cruas-Meysse reactor 4 and proved to be effective, as it brought the clogging level down to about 15%. However EDF's overall control of the operation was not as well-managed as anticipated and was thus improved the next times the process was used on six reactors, in 2007 and 2008, including four 900 MWe and two 1300 MWe.

Owing to the problems encountered in managing the consequences of the cleaning process on the other steam generator components, EDF began to use another process, at lower temperature, with a lesser impact. By 2008, this process was used on the steam generators of three reactors, including two 900 MWe reactors and one 1300 MWe reactor.

However, despite their effectiveness in bringing down the clogging levels in the steam generators treated, ASN considers that these cleaning processes have an undeniable impact, whether on the steam generator internal structures, particularly with high-temperature washing, or on the tube bundle. Stray signals of undetermined origin can appear randomly during the eddy current testing of the tube bundle, whether after cleaning or after an operating cycle.



Mechanical plug installed in steam generator tube bundle

ASN also asked EDF to propose solutions to limit the appearance and development of oxide deposits. Chemical conditioning of the secondary system and the geometry of the support plates would seem to be the main factors involved, so EDF intends to modify reactor operating conditions in order to limit the occurrence of the clogging phenomenon.

In response to the ASN requests, EDF extended its studies concerning the impact of clogging on the safety of the 900 MWe and 1300 MWe reactors.

ASN together with IRSN assessed the justifications provided by EDF concerning its understanding of the clogging phenomenon and the long-term operating safety of all the reactors. EDF is also drawing up a long-term strategy for treatment of this problem, which is proving to be more complex than initially anticipated.

For the recent steam generators, or those in reactors with high pH in the secondary system, a low secondary system pH would seem to encourage the occurrence of clogging. EDF is therefore examining a new and less aggressive washing process.

Tubes with support anomaly

On 18 February 2008, a leak from the primary to the secondary system was detected on the Fessenheim 2 reactor. The origin of this leak was the cracking of a "tube with support anomaly". This incident was rated 0 on the INES scale.

During reactor operation, the steam generator tube bundles are subject to vibration. This vibration can create rapidly developing circumferential fatigue cracking. In order to minimise the amplitude of this vibration and prevent this type of damage, some tubes are held at the top by anti-vibration bars. During steam generator manufacture, some of these bars were incorrectly positioned, leading to inadequate tube support. These tubes are said to be "tubes with support anomaly".

Two steam generator tube breaks, originating in vibration fatigue cracking of "tubes with support anomaly" occurred in North Anna (USA) in 1989 and Mihama (Japan) in 1991. Following these two events, ASN asked EDF in the early 1990s to define a vibration susceptibility criterion for the "tubes with support anomaly" and, based on this criterion, to plug the most susceptible tubes. Since then, on the steam generators of the thirty-four 900 MWe reactors, about 1500 tubes have been plugged on the basis of this criterion. This approach was also adopted internationally by other nuclear reactor licensees.

Pending analysis of the event, ASN asked EDF in April 2008 on the one hand to continue with its investigations to precisely identify the causes of cracking of the tube concerned, and on the other to preventively plug all the steam generator tubes with support anomaly in the reactors in operation in France.

ASN also asked for reinforced measures aimed at early detection of a risk of steam generator tube break.

At the same time, as the calculations performed in the 1990s did not reveal the need to plug the tube which caused the leak in the Fessenheim plant, corrections were made to the previous studies. In this way, they provided an explanation of the event by revealing the cracked tube's susceptibility to vibration fatigue.

These new results show greater tube sensitivity to vibration instability in certain steam generator models installed on the 900 MWe reactors. EDF has undertaken to plug about 2500 tubes for which this would seem to be the most urgent and has reduced the power of some reactors to diminish the risk of vibration, until such time as they can be plugged during the next reactor outage.

With regard to the 1300 MWe reactors, the corrected studies show no significant rise in the coefficients characterising susceptibility to vibration fatigue, which comprise a greater margin than on the 900 MWe reactors.

For N4 reactors, the secondary fluid circulation conditions enable the steam generators to be kept clean, offering short-term guarantees of the absence of aggravating factors such as clogging or head restraint.

Given the drawbacks of large-scale plugging of tubes with support anomaly on the 1300 MWe reactors, ASN considered that the possibility of more closely targeted plugging should be examined. Therefore in the light of the new data presented, ASN considered that the measures necessary in the short term had been taken and suspended its request for plugging of all the tubes with support anomaly until the end of 2008.

ASN however considers that the long-term strategy for treatment of the vibration fatigue phenomenon presented by EDF needs further justification. ASN therefore asked EDF in September 2008 to submit a new strategy incorporating the envisaged measures for reducing the risk of vibration instability on the tubes with support anomaly that were to be kept in service. The investigations will in particular concern the means that could be used to detect known aggravating factors, including head restraint, and to increase the surveillance of tubes with support anomaly, as well as the revision of certain susceptibility studies.

Plug installation anomaly

When treating tubes with support anomaly and during more routine maintenance operations, EDF carries out tube plugging. This operation consists in blanking off the tube inlets and outlets using plugs fixed to the tube walls by a spline and groove insertion system. Although there is considerable operating experience feedback concerning the effectiveness of these operations and the durability of the plugs, the anomalies encountered this year on the Saint-Alban 2 reactor have called into question the reliability of this type of operation. Following the hydro-test on this reactor, EDF on 13 May 2008 observed that a plug which had just been installed in accordance with the NPP procedures, had disappeared. The plug had shifted under the forces generated by the test pressure and was found at the other end of the tube. This anomaly, which was detected before the system was returned to service, had no safety consequences for the reactor. However, had a plug ejection such as this occurred during reactor operation, it could have led to breakage of the tube concerned, as happened in 1989 on the North Anna 1 reactor (United States).

An additional review of the plugs installed on Saint-Alban 2, revealed that three other plugs, still present in the tubes, had also been incorrectly installed.

At the request of ASN, EDF extended the plug installation reviews to all the reactors undergoing an outage. These checks showed that a plug had also been incorrectly positioned on a steam generator in the Penly 2 reactor. These generic anomalies were rated at level 1 on the INES scale.

EDF now carries out checks before and after each tube plugging operation, to guarantee that the plugs are correctly installed. EDF has also undertaken a programme of TV inspection of all the plugs already installed in the reactors in operation, to check for any visible anomalies.

3 | 5 Containment

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

The results of the ten-yearly outage tests for the 900 MWe reactor containments have so far shown leak rates that comply with the regulations. Their ageing was reviewed in 2005 as part of the 30-year periodic safety review, to

Flamanville nuclear power plant (Manche *département*)

assess their leaktightness and mechanical strength for a further 10 years. This review brought to light no particular problem liable to compromise the length of the service life. As part of this review process, EDF carried out studies to check the correct operation of the equipment access hatch in the reactor building in an accident situation. The studies and the modifications identified by EDF were examined during the GPR meeting of 20 November 2008 to close the thirty-year safety review of the 900 MWe reactors.

The results of the ten-yearly outage tests on the 1300 MWe and 1450 MWe reactor containments showed that the leak rate from the inner wall of some of these containments was rising. This was primarily the result of the combined effect of concrete deformation and the loss of pre-stressing of certain cables. Although account was taken of these phenomena at the design stage, they were sometimes underestimated. Consequently, in the event of an accident, certain wall areas would be liable to crack, leading to leaks. To combat this phenomenon, EDF has implemented a preventive repair programme aimed at restoring the tightness of the most heavily affected areas. On the basis of a recommendation from the GPR convened on this subject in early 2002, ASN gave EDF its approval of the strategy. This work is done at each ten-yearly outage. At the end of 2008, fifteen of the twenty four reactors have been completely treated. All the reactors concerned will have undergone the necessary maintenance work by 2012.

3 | 6 Pressure vessels

Owing to the energy that they could release in the event of failure, regardless of the possibly hazardous nature of the fluid (liquid, vapour or gas) that would then be released, pressure vessels entail risks that must be kept under control.

This equipment (containers, exchangers, piping, etc.) is not specific to the nuclear industry and is installed in many industrial sectors such as chemistry, oil refining, paper-making and refrigeration. It is therefore subject to regulation set by the minister for Industry, who imposes the requirements with a view to guaranteeing its safe manufacture and operation.

The equipment items in this category liable to emit radioactive releases in the event of a failure are called nuclear pressure vessels and are regulated by the order of 12 December 2005 (see point 2|2|1, table 2, of chapter 3). In addition to the requirements applicable to conventional pressure vessels and the existing texts covering reactor primary and secondary systems, this order imposes additional safety requirements on nuclear pressure vessels. The manufacturers and licensees have five years to implement them. The existing regulatory texts concerning steam and gas pressure vessels remain applicable during this transitional period.

ASN is also contributing to monitoring the enforcement of the regulations concerning the operation of the non-nuclear pressure vessels in NPPs. This monitoring consists, especially through on-site checks, in ensuring that EDF is implementing the measures required of it. ASN actions in 2008 include audits and surveillance visits of the NPP inspection departments. These departments, under the responsibility of the licensees, are responsible for carrying out inspections to ensure the safety of pressure vessels. However, these departments currently only deal with non-nuclear pressure vessels. Their competence could be extended to nuclear pressure vessels, once the requirements associated with this equipment, especially those corresponding to its safety roles, have been correctly defined.

Of the events that occurred in 2008 on the pressure vessels, except for the primary and secondary systems which are dealt with in point 3|4, damage linked to system corrosion and erosion occurred in many areas of the secondary systems, indicating shortcomings in the monitoring methods and programmes defined by EDF. ASN will continue to review the measures envisaged by EDF, to ensure that an appropriate replacement and inspection programme for this equipment is put into place. Cracks were also discovered in 2008 on a number of nozzles installed on the RCV system letdown line (see point 1|1|5). These cracks potentially entail a risk of a primary break on the lines in the event of a guillotine failure. The origin of these cracks, one of which is penetrating, is the vibration fatigue phenomenon, a scenario which had not been considered by EDF. ASN considers that EDF must learn the appropriate lessons from these events that occurred on the Chinon, Cruas-Meysse and Saint-Laurent-des-Eaux NPPs. To do this, ASN considers that EDF needs to update its monitoring and inspection strategy for the areas subject to vibration fatigue.

3|7 Protection against external hazards

3|7|1 Earthquakes

Buildings and equipment of importance for the safety of NPPs are designed to withstand earthquakes of an intensity greater than the most severe earthquakes that have ever occurred in the region of the NPP. 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.

Although there is no particularly strong seismic risk in France, this topic is the subject of considerable efforts on the part of EDF and sustained attention by ASN.

Updating of the design rules

Several years ago, ASN began work on updating the rules dealing with the seismic risks in BNIs.

In 2001, basic safety rule (RFS) 2001-01 dealing with determining the seismic risk for surface BNIs (except for long-term radioactive waste disposal facilities) replaced a rule dating from 1981.

RFS V.2.g concerning seismic calculations of civil works was revised and published in 2006, in the form of a guide for including the seismic risk in the design of surface BNI civil works. It is the result of several years of work by French experts in the anti-seismic engineering field.

For surface BNIs and based on NPP data, this text defines the anti-seismic design requirements for civil works and the acceptable methods for:
- determining the seismic response of these works, by considering their interaction with the equipment they contain and assessing the associated loads to be used in the design;
- determining the seismic movements to be considered for the design of the equipment.

The anti-seismic design provisions for civil works and the associated methods are defined for the new surface BNIs in ASN guide 2/01 of 26 May 2006 concerning the inclusion of the seismic risk in civil works for BNIs, other than radioactive waste long-term repositories.

Seismic design reviews

Within the framework of the current periodic safety reviews (see point 2|2|3), the seismic design review in particular consists in updating the level of the earthquake to be taken into account, under application of RFS 2001-01.

For the thirty-year safety reviews on the 900 MWe reactors, ASN asked EDF to examine the seismic design of the electrical buildings of CPY reactors and analyse the risk the turbine hall represents for the electrical buildings. For CP0 reactors, ASN asked EDF to study the seismic design of the nuclear island buildings and the turbine hall. The studies led to the definition of changes involving strengthening of equipment or structures, which will be implemented starting in 2009. The conclusions of these studies and the modifications identified by EDF were reviewed at the GPR meeting of 20 November 2008 dedicated to closure of the thirty-year safety review of the 900 MWe reactors.

With regard to the twenty-year safety review of the 1300 MWe reactors, EDF studied the earthquake stability of the reactor turbine hall and the strength of the civil works of the electrical building and backup auxiliaries. These studies brought to light the fact that the original design guaranteed the resistance of these reactors to the earthquakes reassessed according to RFS 2001-01, provided that additional justification data was provided concerning protection of the electrical building civil engineering structures and safeguard auxiliaries of P'4 reactors from the risk presented by the turbine hall.

In preparation for the forthcoming seismic reviews (forty-year review for the 900 MWe reactors and thirty-year review for the 1300 MWe reactors), ASN set up a working group comprising EDF, IRSN and ASN. The aim of this working group is to determine the reference earthquakes to be considered for these forthcoming reviews.

ASN is also taking part in a working group comprising the General Directorate for the Prevention of Risks (DGPR) as well as IRSN and the French Geological and Mining Research Office (BRGM). The aim of this working group is to compare the contingencies taken into account and the construction design of both installations classified on environmental protection grounds (ICPEs) and BNIs.

3 | 7 | 2 Flooding

Following the flooding of the Blayais NPP in December 1999, EDF began to reassess the off-site flooding risk and the protection of all of its NPPs against this risk. This reassessment mainly concerns a revision of the maximum design flood level (CMS). The revised CMS takes account of the additional causes of flooding, such as particularly heavy rain, dam failure and rising groundwater. The measures to be taken for the reactors in the event of a rise in the water level was also reassessed. A file was produced for each NPP and protection improvement works have been defined.

In October 2007, EDF completed the work made necessary by the flood risk reassessment, with regard to the risks of water ingress.

The ASN considers that the progress of studies and work is as expected. For the particular case of the Tricastin NPP, EDF carried out additional studies into the risk of dam failure, a subject on which ASN will issue a decision in 2009.

In order to finalise the overall approach to the off-site flooding risk for EDF reactors, but also for other NPPs, ASN asked the Advisory Committee for nuclear reactors (GPR) and the Advisory Committee for laboratories and plants (GPU) for their opinions.

ASN followed the recommendations of the Advisory Committees and issued six particular demands concerning the risk of dam, system or equipment failure, the flooding risk, protection against rainfall and protection of the Tricastin NPP.

ASN also asked EDF to continue its exchanges with the concession-holders of the works to be strengthened as part of the thirty-year safety review of the 900 MWe reactors.

At the same time, the working group for revision of RFS I.2.e to deal with the flooding risk, continued its activities in 2008. This group consists of experts from IRSN, licensee representatives and ASN. The new BNI flooding risk protection guide will cover the choice of unexpected events likely to lead to flooding of the NPP, and the methods used to characterise such events. It will concern all the BNIs.

ASN is also taking part in updating the IAEA guide concerning the off-site flooding risk for nuclear sites. There are a number of objectives:
– to incorporate operating experience feedback;
– to include climate change studies;
– to finally obtain a single guide (replacing the various IAEA guides on the subject);
– to take account of new phenomena;
– to take account of all NPPs.

This guide should be published in February 2010.

3 | 7 | 3 Heat wave and drought

The exceptionally hot weather conditions observed since the summer of 2003 have resulted in a significant reduction in the flow and a considerable rise in the temperature of the watercourses constituting the heat sink for certain NPPs. They also led to high air temperatures, in turn raising the temperature inside NPP premises.

During these episodes of heat wave and drought, it became clear that some of the physical limits used in the design of NPPs or stipulated in their GORs, had been reached.

For CPY reactors, ASN in 2006 therefore undertook a review of the “heat wave” reference documentation proposed by EDF, in order to reassess the operation of the NPPs in conditions harsher than those included in the design. ASN adopted a stance on a part of this reference documentation in 2007. EDF developed similar reference documentation for CP0 reactors. For the 900 MWe reactors, ASN will clarify its position in 2009 on the entire reference documentation, when it issues its decision regarding the continued operation of these reactors. This reference documentation was also produced for N4 reactors and is currently being drafted for P4 and P'4 reactors.

ASN is taking part in the heat wave surveillance process and on this particular issue, ASN defined its role and set up a decision-making process to be activated in the event of a heat wave.

3|7|4 Fire

The fire risk in EDF NPPs is handled using the principle of defence in depth, based on three levels: NPP design, prevention and fire-fighting.

The NPP design rules should prevent the spread of any fire and limit its consequences. This is primarily built around:
– the principle of dividing the NPP into sectors in order to keep the fire within a given perimeter, each sector being bounded by sectoring elements such as doors, fire-walls, fire-dampers, etc.) offering a fire resistance rating specified in the design;
– protection of redundant equipment performing a fundamental safety function.

Prevention primarily consists in:
– ensuring that the nature and quantity of combustible material present in the premises remains below that of the scenarios used in the design of the sectoring elements;
– identifying and analysing the fire risks. In particular, for all work liable to cause a fire, a fire permit must be issued and protective measures must be taken.

Fire-fighting should enable a fire to be tackled, brought under control and extinguished within a time compatible with the fire resistance rating of the sectoring elements.

Design

With regard to design, EDF is completing deployment of the fire-fighting action plan (PAI), to ensure the conformity of and improve fire protection for the 900 MWe and 1,300 MWe reactors. In 2006, ASN noted that the work to renovate the technical and electrical cable ducting was behind schedule. In 2008, during its inspections and six-monthly meetings with EDF, ASN checked completion of the work and compliance with the end of 2008 deadline.

During the reviews carried out in 2006, ASN also identified problems with management of loss of sectoring, whether scheduled (for example, when implementing the PAI) or inadvertent. At the request of ASN, EDF proposed a sectoring management reference system which is currently being implemented on NPPs. This reference system is being assessed by ASN and IRSN. ASN will adopt a stance on it in 2009, taking account of the operating experience feedback from the inspections it carried out in the NPPs in 2008.

Finally, for CPY reactors, ASN in 2007 asked EDF to continue with studies into modification of the smoke control system in the electrical buildings. The aim is to restore sectoring of the premises through which the circuits of this system pass and ensure smoke evacuation in the event of a fire, in order to facilitate personnel evacuation and fire-fighting. ASN received EDF's answer at the end of 2008 and it will be assessed by ASN and IRSN in 2009.

Prevention

Preventing fire breaking out and spreading is primarily based on correct management of combustible materials, whether present permanently in the premises, or only temporarily, in particular during reactor outages. In 2007, EDF sent ASN a new reference system designed to optimise the management of combustible materials. ASN will adopt a stance on it in 2009 on the basis of a review conducted by IRSN.

Preventing fire breaking out and spreading is also based on the quality of the fire permits, in particular the risk assessments and the effective implementation of protective measures in the field.

In the light of the inspections conducted in 2007 and 2008, ASN considers that EDF needs to further improve how the protective measures are implemented as well as the training of those responsible for drafting the fire permits.

Fire-fighting

In 2008, ASN focused on checking the conformity of the NPPs with the order of 31 December 1999 (see point 2|2|1 of chapter 3) concerning justification of the adequacy of the fire-fighting organisation implemented. EDF also presented ASN with an approach justifying compliance with these requirements, on the basis of its internal reference documentation. Subsequent to this presentation, ASN asked EDF to define a programme to implement and check the adequacy of the provisions of its reference documentation on each NPP. In addition, during the inspections carried out in 2008, ASN observed that the response teams were deployed as soon as the alarm was triggered, rather than following confirmation of the fire and that the fire-fighting response times were very slightly improved. ASN also considers that EDF needs to continue with its fire-fighting efforts, in particular with regard to the actions of the response teams and improving interfacing with the off-site emergency services.

A meeting was held on 16 December 2008 between the EDF NPP directors, the Directorate for Civil Security (DSC) and ASN to conduct an in-depth analysis of the areas for improvement identified in 2006. These areas concern the interface between the organisations, assessment of the risks and definition of the response scenarios and means or resources to be deployed in the event of a fire. The secondment by the Departmental Fire and Emergency Response Department (SDIS) of a professional fire officer to each NPP and the drafting of national response scenarios with a schedule for implementation on NPPs, were in particular reviewed. With regard to the response scenarios, ASN will in 2009 focus on checking that the scenarios established and validated by EDF and the DSC are implemented on each NPP and will check that the establishments listed for emergency response purposes (ETARE) are updated.

3 | 7 | 5 Explosion

Of the accidents liable to occur in an NPP, explosion is a potential major risk. The explosion can damage elements that are essential for maintaining safety or may lead to failure of the containment with the dispersal of radioactive materials into the NPP or into the environment. Steps must therefore be taken by the licensees to protect the sensitive parts of the BNI against the risk of explosion.

In 2005, ASN asked EDF to take greater account of the risk of internal explosion. As part of the thirty-year safety review for the 900 MWe reactors, ASN therefore asked EDF to review the existing means of protection against the effects of an internal explosion. It also asked it to initiate a similar approach for the other plant series. This approach is in progress for the 1450 MWe reactors. In 2008, ASN asked EDF to clarify how it was initiating this approach for the 1300 MWe reactors.

The reference system for dealing with the risks of internal explosion inside NPPs was transmitted in 2006 by EDF. The safety case presented in this reference system is based on the implementation of prevention and surveillance measures. EDF supplemented its studies by including gases other than hydrogen and by extending its analyses to buildings other than those housing the reactors.

This reference system was assessed by ASN and IRSN, whose conclusions were reviewed by the GPR at its meeting of 20 November 2008, dedicated to closure of the thirty-year safety review of the 900 MWe reactors. The changes arising from application of this reference system will be implemented as of 2009 on the Fessenheim and Tricastin NPPs.

During the explosion risk inspections carried out in 2008, ASN detected non-compliance with the requirements of Article 16 of the order of 31 December 1999 concerning piping transporting explosive fluids, in the Blayais, Civaux, Golfech and Cruas-Meysse NPPs (see box).

Pursuant to the TSN Act, ASN issued requirements for controlling the explosion risk in its decision 2008-DC-0118 of 13 November 2008. These requirements, defining the steps to be taken by EDF within three months to deal with control of the explosion risk in all NPPs, concern:
– the creation of an organisation and oversight system such as to guarantee compliance with the regulations concerning the explosion risk;
– review of the conformity of all the explosive fluid piping with the requirements of Article 16 of the order of 31 December 1999;
– an in-depth review of the extent to which account is taken of the explosion risks.

3 | 8 Conventional safety inspection

Pursuant to Article 57 of the TSN Act and the Labour Code, ASN is responsible for monitoring safety and for conventional safety inspection duties in the NPPs. The health, safety and working conditions of the employees of EDF, its contractors and their subcontractors, along with the safety of the NPPs, are now regulated on a coordinated basis by ASN. This regulation takes place at the various stages in the life of the NPPs: construction, operation and decommissioning.

The main duties of the ASN officers in charge of conventional safety inspections are:
– to ensure compliance with labour regulations, by checking that they are effectively and correctly implemented, or by assisting the licensee with assimilation and practical implementation of labour regulations;
– to investigate work accidents and ensure that the licensee is taking the necessary steps to guarantee worker safety;
– to identify and as far as possible prevent any labour conflicts.

Risks to the workers

NPPs are the source of a number of risks to the workers, which are not always linked to the nuclear aspect of the activity. These risks are said to be “conventional”. They for example concern electrical installations, pressurised gas or steam vessels, the chemical products used, the explosion risk of hydrogen circuits, the asphyxia risk from nitrogen circuits, work at height, or handling of heavy loads.

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

It should be noted that the steps such as to guarantee personnel safety may contribute to nuclear safety: this is for example the case with preventing the risk of explosion or

Inspections of 25, 26 September and 24 October 2008 in the Cruas-Meysse NPP

During the inspections carried out on 25, 26 September 2008 and 24 October 2008, ASN checked implementation of the regulations concerning control of the risk of internal explosion in the Cruas-Meysse NPP. Following spot-checks, the ASN inspectors detected several occurrences of failure to comply with the requirements of Article 16 of the order of 31 December 1999.

Article 16 requires:
- *that the piping carrying explosive fluids is suitably maintained;*
- *that it is periodically examined to ensure that it is in good condition;*
- *that the routing of this piping is marked on a drawing that is kept up to date and placed at the disposal of the fire and emergency services;*
- *that it is marked in-situ in accordance with the standards in force.*

The deviations detected during the inspections concern the absence of signalling of the hydrogen piping and of drawings identifying the routing of the explosive fluids, plus a lack of periodic inspection and upkeep of the hydrogen piping.

Following these inspections, ASN drew up a report and notified the Public Prosecutor's Office of non-compliance with Article 16 of the order of 31 December 1999 and served formal notice on EDF to bring the Cruas-Meysse power plant into conformity with the explosion risk requirements stipulated in the regulations, within a period of three months.

fire, of pressurised equipment bursts or falling loads. Similarly, ASN considers that a climate of social tension is hardly conducive to long-term safety. By regularly participating in the meetings of the health, safety and working conditions committees (CHSCT), ASN's conventional safety inspectors not only familiarise themselves with health and safety issues within the NPPs, but also obtain a clearer impression of changes in the social climate and can detect latent or actual labour disputes liable to have an impact on the NPP organisation and therefore potentially on plant safety.

Conventional safety work in 2008

In 2008, the conventional safety inspections carried out concerned health and safety at work. The ASN conventional safety inspectors therefore carried out spot-checks on scaffolding and lifting gear on a number of construction sites.

The ASN conventional safety inspectors also checked the performance (analysis, preparation, scheduling, and multiple contractor coordination) of activities required for the operation and maintenance of NPPs, but which involved risks for the workers:
- cleaning of steam generators and cooling towers, entailing the use of carcinogenic, mutagenic or reprotoxic chemical products. The licensees are urged to take steps to limit worker exposure to these products and to find less harmful alternatives;
- performance of work near the reactor while it is operating at full-power;

Non-compliance with working time limits in the Gravelines NPP

In July 2007, ASN sent the Dunkerque Public Prosecutor's Office a violation report concerning the Director of the Gravelines NPP. This report was drawn up after a number of in-depth inspections on compliance with the regulations concerning the length of working periods. Between March and June 2007, ASN recorded 44 violations of regulations concerning daily rest periods or the maximum weekly and daily working periods for the EDF staff.

The Dunkerque police court on 18 September 2008 sentenced the Director of the Gravelines NPP at the time of the events to a fine of €4,550 for these violations of working time legislation.

ASN also asked the Gravelines power plant management to implement a new organisation in order to comply with the Labour Code. This organisation has been in place since September 2007.

– replacement of equipment containing asbestos, particularly the fire-doors.

The ASN conventional safety inspectors observed anomalies in compliance with the employer and worker obligations with respect to the provision and use of individual and collective protective equipment.

Finally, the ASN conventional safety inspectors carried out checks on compliance with the regulations concerning working hours, especially during reactor outage periods. They again observed anomalies regarding compliance with the maximum working times and rest periods. The parties concerned were reminded of the regulations. Waiver requests were examined and some were rejected. The ASN conventional safety inspectors were required to issue a decision on a number of experiments modifying the organisation of work during reactor outages. These modifications, which were aimed at optimising how the work was organised and which could thus improve safety, nonetheless had significant effects on working rates, conditions and relations, which also have to be taken into account by the licensees.

4 RADIATION PROTECTION AND ENVIRONMENTAL PROTECTION

4 | 1 Personnel radiation protection

In a NPP, exposure to ionising radiations can have a number of origins, including:
– the fuel;
– equipment activated by the neutron flux;
– particles resulting from corrosion of the components of the primary system and carried by the primary fluid.

About 80% of the doses received are linked to maintenance work carried out during reactor outages. In 2008, these doses were distributed among a workforce of about 38,000 EDF staff and EDF's contractor and subcontractor staff, as illustrated in graph 4.

EDF policy

Since the end of the 1990s, EDF has reinforced its radiation protection policy in order to raise the level of requirements to bring them into line with those concerning nuclear safety. EDF therefore implemented a national radiation protection reference system which aims in particular to develop a new organisation of NPPs. With regard to this organisation, ASN considers that EDF has correctly initiated its deployment on NPPs. However, it considers that efforts must be continued in order to achieve the goals of the reference system, particularly with regard to surveillance of radiation protection in the field.

EDF has also implemented a series of projects concerning the technical, organisational and human aspects. These projects aim on the one hand to reduce worker doses in the NPPs to a level that is as low as reasonably achievable and to obtain the best possible level of radiological cleanness in the NPPs. For the purposes of these projects, EDF has set up a computerised dosimetry management system and action plans on NPPs concerning:
– control of radiological cleanness of the primary system;
– entry into controlled areas in work overalls;
– increased presence in the field of personnel from the department with competence for radiation protection;
– reduction of the dose received by the most exposed disciplines;
– definition of the role of the various radiation protection stakeholders.

ASN considers that these projects will lead to improvements in the organisation of radiation protection and the dissemination of a radiation protection culture, to enable EDF to further reduce worker dosimetry in the NPPs, as illustrated in graphs 5 and 6.

ASN assessment and actions taken

In 2008, ASN assessed the responses provided by EDF to the requests made by ASN, on the basis of the recommendations of the 2003 GPR, concerning worker radiation protection in pressurised water reactors. ASN considers that the EDF action plans created to address these requests are on the whole satisfactory. However, ASN asked EDF for additional information concerning the assessment of the performance of radiation protection, the roles of the expanded committee for radiation protection issues pursuant to Article 37 of the TSN Act and the optimisation methods and tools.

At the same time, ASN continued to check implementation of radiation protection requirements. In this respect, ASN examined how radiation protection is taken into account in preparing and implementing changes to the primary system purification circuits on P4 and P'4 reactors. ASN considers that efforts were made to promote good radiation protection when implementing the change. However, ASN considers that EDF needs to improve the dose forecast evaluations, the optimisation approach, operational radiation protection and the incorporation of operating experience feedback.

ASN also observes no appreciable improvement in the behaviour of the intervention staff and in the assimilation of training. It considers that EDF must improve the content of the radiation protection qualifying training for access to controlled areas and ensure that it is assimilated by the staff. Finally, progress is still needed in surveillance of the implementation of radiation protection rules in the field, particularly with regard to collective protection designed to prevent the dispersion of contamination.

4 | 2 Discharges from NPPs

4 | 2 | 1 Discharge licence revision

In 2008, ASN continued to review the effluent discharge and water intake licence renewals for NPPs, initially issued in accordance with the provisions of decree 95-540 of 4 May 1995 concerning the discharge of liquid and gaseous effluents and water intake by BNIs. These licences, issued by the *préfets*[3] under the previous regulations in this respect, comprise a stipulated validity limit.

ASN's aim is for the majority of the existing licences to be reviewed in order to ensure greater harmonisation among the various NPPs. Since the publication of decree 2007-1557 of 2 November 2007 (see chapter 5, point 3 | 1), the new licences now take the form of ASN decisions, subject to approval by the ministers responsible for nuclear safety and radiation protection, when the provisions concern environmental discharge limits.

These licences concerning water intake and all BNI discharges set the quantities, concentrations and surveillance methods with regard to the pollutants liable to be contained in the discharges and in the environment, in accordance with the order of 26 November 1999. On the occasion of these licence renewals, ASN applies the following principles:
- with regard to radioactive discharges, the real discharges from NPPs are constantly falling and are well below the limit values hitherto in force, so ASN is reducing these limit values. For the 900 MWe and 1,300 MWe reactors, it has set new limit values based on the operating experience feedback from real discharges, while taking account of the unexpected events occurring during routine operation of the reactors. The discharge limits have thus been cut by a factor of between 1 and nearly 40, depending on the current fuel management parameters. They have however been raised by a factor of 1.25 for liquid tritium discharges, assuming future "high burn-up fraction" fuel management;
- with regard to non-radioactive materials, ASN decided to cover the regulated discharges more broadly, aiming for a more exhaustive approach than in previous licences.

At the end of 2008, fourteen NPPs held new effluent discharge and water intake licences. In particular, the NPPs at Penly and Tricastin had new licence requirements set by ASN in 2008. Filing of the licence renewal applications will be staggered until 2011.

4 | 2 | 2 Procedures carried out in 2008

Complete revision of the effluent discharge and water intake licences

In 2008, ASN completed its review of the effluent discharge and water intake files for the Penly and Tricastin NPPs. Effluent discharge and water intake at Penly are now regulated by ASN decisions 2008-DC-0089 and 2008-DC-0090, dated 10 January 2008 and published in the ASN official bulletin on its website. Decision 2008-DC-0090 setting the environmental discharge limits was approved by the order of 15 February 2008 from the ministers responsible for nuclear safety and radiation protection. The effluent discharge and water intake for the Tricastin NPP are regulated by ASN decisions 2008-DC-0101 and 2008-DC-0102 of 13 May 2008, published in the ASN official bulletin on its website. Decision 2008-DC-0102 setting the environmental discharge limits was approved by an order of 8 July 2008 from the ministers responsible for nuclear safety and radiation protection.

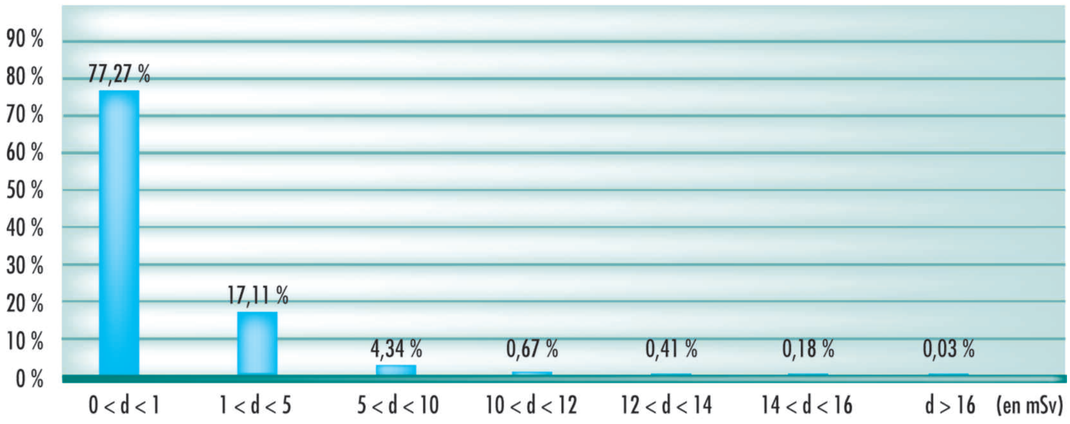
ASN also continued to review the effluent discharge and water intake files for Chooz, Civaux, Dampierre-en-Burly and those concerning the two reactors in operation on the Flamanville NPP, plus the EPR reactor currently under construction. The public inquiry concerning the Civaux file was held from 7 October to 13 November 2008.

Partial revisions

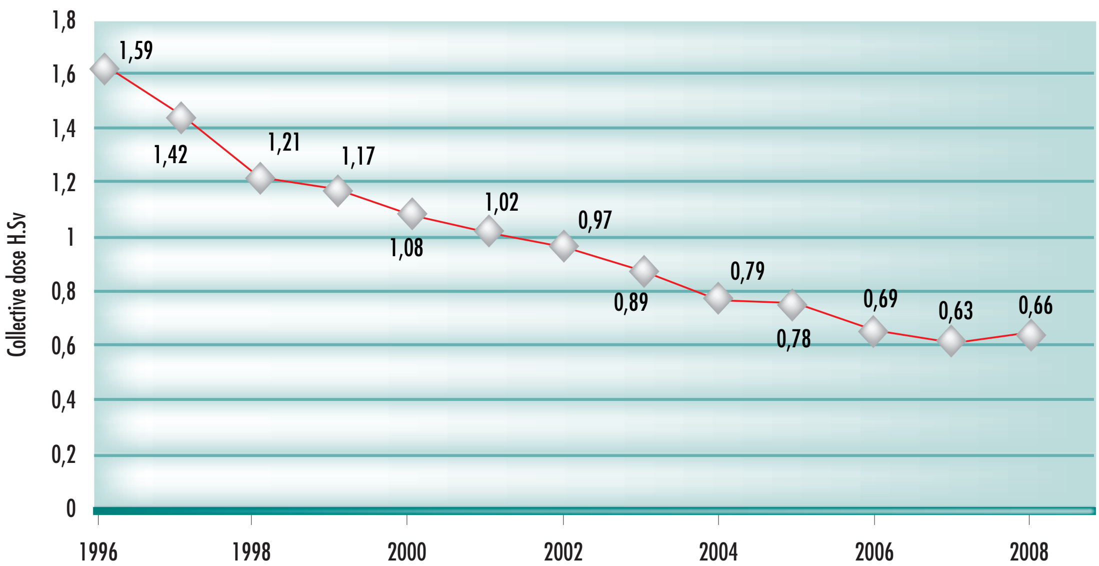
Review of the applications for modification of the effluent discharge and water intake licence orders continued in 2008 for:
- the Belleville-sur-Loire and Cruas-Meysse NPPs (regulated by the orders of 8 November 2000 and 7 November 2003 respectively): the applications mainly concern a revision of the limit values for tritium discharges and for certain chemical parameters such as metals (copper and zinc), changes to the method of conditioning the

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

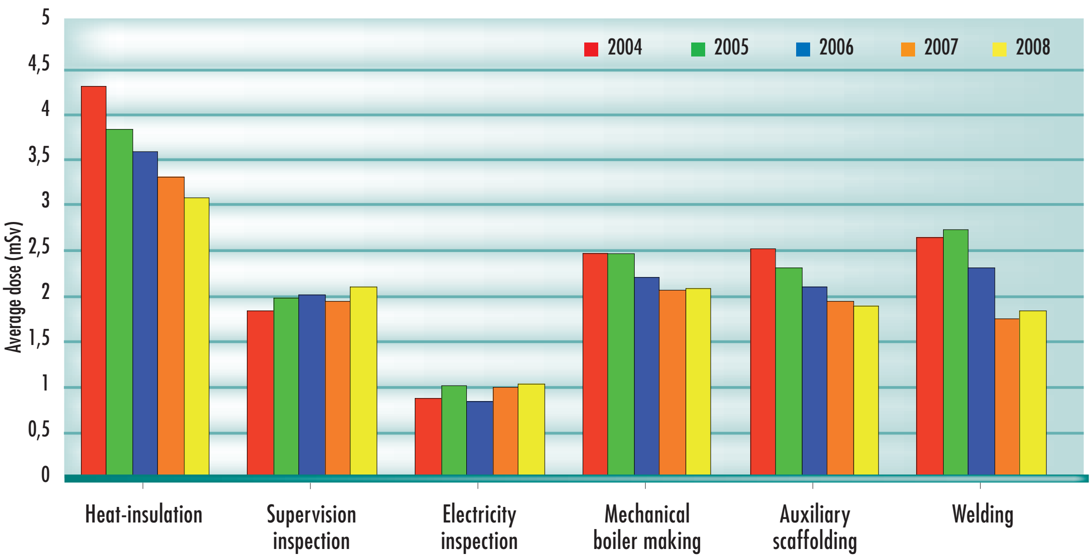
Graph 4: breakdown of the population per dose range for the year 2008 (EDF data)



Graph 5: mean collective dose per reactor (EDF data)



Graph 6: changes in mean individual dose according to categories of workers involved in reactor maintenance (EDF data)



secondary systems and the use of biocidal treatment against scaling of the condenser cooling systems;
– the Chinon NPP (regulated by the order of 17 August 2005 amending the order of 20 May 2003): the application concerns measurement of the cooling system purge flow rate;
– the Paluel NPP: the application mainly concerns a revision of the limit values for tritium discharges and changes to the chemical parameters for the method of conditioning the secondary systems;
– the Saint-Alban NPP (regulated by the order of 29 December 2000): the application concerns a revision of the limit values for nitrogenated discharges, suspended solids and pH;
– the Saint-Laurent-des-Eaux NPP: the application concerns a revision of the tritium discharge limit values and the use of biocidal and anti-scaling treatment in the condensers cooling circuits. This file also contains applications concerning discharges linked to the decommissioning of the NPP's gas cooled reactors.

Finally, pursuant to Article 26 of decree 2007-1557 of 2 November 2007, a number of NPPs submitted notifications concerning the dredging of their water intake or discharge structures (Chinon, Dampierre-en-Burly and Flamanville) or the increased surveillance of the groundwater, through the creation of new observation wells (Chooz, Flamanville, Saint-Alban). These operations and the dredging work at Flamanville were expressly approved by ASN without modification of the effluent discharge and water intake licences for these NPPs.

Particular operations

Clogging of the steam generator support plates was brought to light on several of the French nuclear power reactors (see point 3|4|4). In order to remedy this clogging phenomenon, EDF decided to use two forms of chemical washing on the reactors concerned, one called HTCC and the other called EPRI/SGOG. The work began in 2007 and continued in 2008 on the Belleville-sur-Loire 1 reactor, the Chinon 4 reactor, Cruas-Meysse reactors 2 and 3 and Saint-Alban reactor 2. These washing operations create unusual discharges, especially ammonia from the HTCC process.

Pursuant to Article 26 of decree 2007-1557 of 2 November 2007, EDF notified ASN of the NPP modifications resulting from use of the chemical washing processes, particularly with regard to the discharge of liquid and gaseous effluents and the use of the equipment necessary for these operations. Based on the data presented in the EDF files (particularly the demonstration that there were no impacts around the NPP boundary, the discharge surveillance measures taken and the steps taken to inform the neighbours and local residents), the operations were expressly approved by ASN without modification of the discharge licence concerning these NPPs.

Examination of management of radioactive and non-radioactive effluents

In 2006, ASN decided to consult the GPR about the management of radioactive effluents and certain non-radioactive effluents from the French NPPs in service and the various means of improving it. This examination concerns the liquid and gaseous radioactive effluents and the associated chemical substances involved in normal operating situations.

The technical review conducted by IRSN continued in 2008. The GPR meeting is scheduled for 2009.

4|2|3 Radioactive discharge values

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

The 2008 results concerning radioactive effluent discharges are presented in graphs 7 and 8. Graph 7, "liquid radioactive discharges", presents the 2008 discharges of liquid tritium and others (carbon 14, iodine 131, nickel 63 and other beta and gamma emitting radionuclides) per pair of reactors. Graph 8, "gaseous radioactive discharges", presents the 2008 discharges 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.

Radiological impact of discharges

The calculated radiological impact of the maximum discharges given in the EDF licence applications for the most exposed population group, does remain within the dosimetric limit acceptable for the public.

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

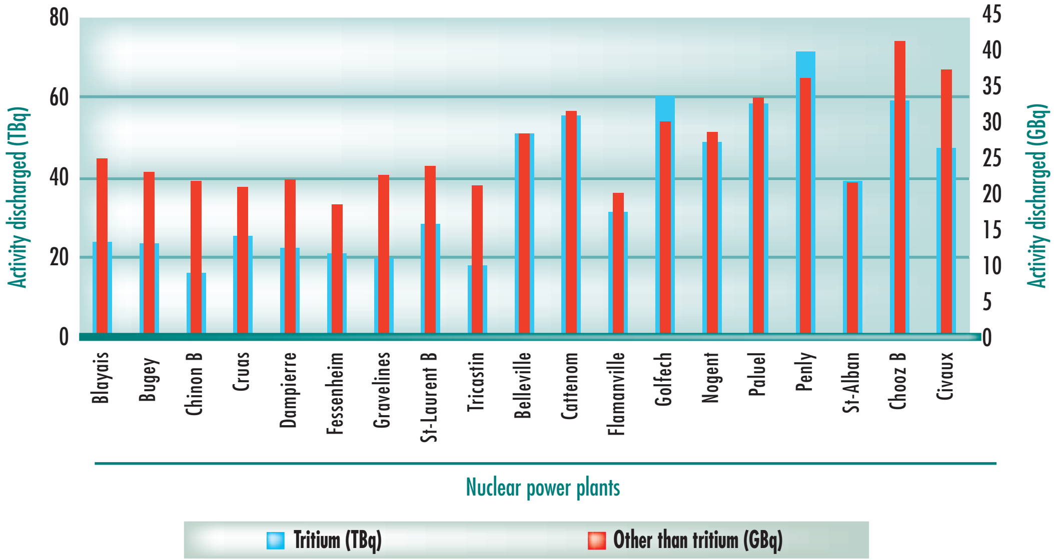
For example, the annual effective dose corresponding to the limit values requested by EDF for renewal of the Penly NPP licence, was evaluated at 19 µSv per year. As the actual discharges from the Penly NPP in 2008 were lower than the specified discharge limits, the actual annual effective dose in 2005 is less than this value.

4|3 Technological waste management

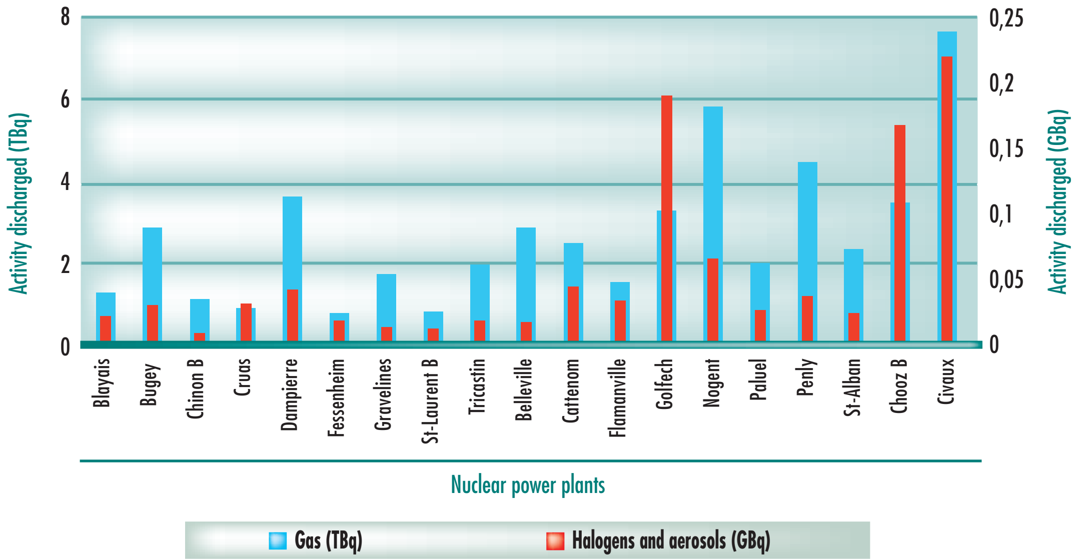
Waste management operations

Most of the operations associated with management of the waste resulting from the operation and maintenance of

Graph 7: liquid radioactive discharges



Graph 8: gaseous radioactive discharges



nuclear reactors take place in nuclear auxiliary buildings (BAN), waste auxiliary buildings (BAC) and liquid waste discharge system buildings (BTE). Following inspections which brought to light unsatisfactory waste management in terms of radioactive materials containment, fire protection and radiation protection, ASN asked EDF to improve waste management on NPPs and to define operating requirements concerning waste management in the BAN, BAC and BTE buildings. EDF inventoried the buildings, compared current practices with those defined in the design documents, and gradually reduced the quantities of waste stored in these buildings. On this last point, ASN observed the efforts made by EDF in terms of packaging and evacuation in order to reduce the quantities involved.

In 2008, EDF continued work on drafting the waste management requirements: the management principles and operating rules were improved and work was started on checking their applicability on NPPs. These requirements should be forwarded to ASN during the course of 2009, which will enable ASN to determine whether they are likely to remedy the situations previously observed.

Waste with no disposal solution

A certain amount of waste from contaminating areas (monitored zones, controlled areas) such as batteries, electronic devices, LED lighting, etc., currently has no disposal solution.

Most of this particular waste is legacy waste. Improvements in routing this waste to conventional or nuclear disposal facilities and in waste classification has minimised the production of some of this waste without disposal solution, in particular batteries and LED lighting.

ASN asked EDF to draw up an inventory of the types of waste concerned for the plants in operation and estimate the quantities present on NPPs as compared with the storage capacities.

Furthermore, as the quantity of electronic waste is bound to increase, given the greater use of electronic equipment, hardware and components, ASN asked EDF to initiate the necessary investigations to estimate future quantities.

4 | 4 Protection against other risks and problems

4 | 4 | 1 The microbiological risk

Management of the bacteriological risk in NPPs is a health issue, owing to the severity of the potential infections, but also an environmental one, given the impacts of the discharges resulting from biocidal treatment.

Amoebae

As stated in point 1 | 1 | 1, the condenser is a heat exchanger used to cool the secondary systems. The older exchangers are made of brass while the more recent ones are made of stainless steel or titanium, because they lead to fewer metal releases through wear than brass (the origin of the copper and zinc releases).

Amoebae, which are micro-organisms that can be pathogenic, do not develop in circuits fitted with brass condensers, owing to the toxicity of copper for them, but can develop in the renovated exchangers.

In order to comply with the limit value set by the health authorities, the NPPs at Bugey, Chooz, Dampierre-en-Burly, Golfech and Nogent-sur-Seine carry out biocidal treatment with monochloramine, leading to discharge of chemical substances. These discharges are regulated by requirements issued by the authorities. The Civaux NPP uses UV radiation to disinfect the discharged cooling water because the Vienne river into which the discharge flow is more susceptible to chemical treatment discharges.

During the 2008 campaign, no instance of the pathogenic amoeba concentration being exceeded downstream of the NPPs was observed.

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

Legionella

Legionella are micro-organisms which can be pathogenic. They can develop in NPP cooling towers, which offer conditions propitious to the development of bacteria and their dispersal in the plume of steam they discharge.

The legionella concentrations in secondary system cooling systems of NPPs with cooling towers are variable and depend on a variety of factors (time of the year, scaling, quality of make-up water, use of anti-amoeba treatment, etc.). They can reach up to several hundred thousand colony forming units per litre (CFU/l - indicating the number of micro-organisms per unit of volume), or even more than a million for those plants not using treatment: Belleville-sur-Loire, Cattenom, Cruas-Meysse, Dampierre-en-Burly (reactors 2 and 4) and Saint-Laurent-des-Eaux. They remain less than one hundred thousand CFU/l at Bugey, Chooz, Civaux, Dampierre-en-Burly (reactors 1 and 3), Golfech, Nogent-sur-Seine and Chinon, the last NPP equipped with a monochloramine treatment station.

To enhance legionella risk prevention, ASN together with the General Directorate for Health (DGS) in 2005 required that EDF comply with maximum legionella concentration limits in the cooling systems, along with installation surveillance requirements. ASN observes that the limits it set are adhered to by all NPPs. Moreover, to date, no cluster of legionella cases has been attributed to a large cooling tower on a NPP.

At the same time, and jointly with DGS and DGPR, ASN contacted the French Agency for Environmental and Occupational Health Safety (AFSSET) for its opinion on the evaluation of the health and environmental risks associated with the presence of legionella in the cooling systems of NPPs, in order to obtain a clearer assessment of the studies conducted by EDF and the general risk prevention and surveillance strategy.

Two opinions were forwarded by AFSSET in 2006 and 2007. After being critical of the approach and measures adopted by EDF in 2006, AFSSET considers that the action plan proposed by EDF at the end of 2007 contained significant improvements. It does however consider that EDF needs to continue its efforts with respect to risk analysis, tightening up the surveillance plans, improving inspection procedures and evaluating additional solutions.

Legionella concentration levels in the large NPP cooling towers

The legionella concentrations not to be exceeded in the secondary system cooling systems are 5.10^6 CFU/l for NPPs with large cooling towers (about 150 m high), and 5.10^5 CFU/l for the Chinon NPP with its smaller cooling towers (28 m). For the systems other the secondary systems cooling circuits (air-conditioning for example), implementation of the requirements in force for ICPEs is requested (lower limits for ICPE cooling towers).

Since 2005, the Chinon NPP has been equipped with a monochloramine legionella treatment unit. This NPP, which required updating of the discharge and water intake licence, enables the licensee to meet the maximum legionella concentration level set by ASN.

For the other power plants which do not use specific treatment, the value of 5.10^6 CFU/l is met by means of the preventive measures usually employed by EDF to limit the development of biofilm and the formation of scale in its systems.

In the light of the AFSSET opinions, ASN asked EDF to:
- keep the colonisation levels as low as reasonably achievable;
- enhance the surveillance of its NPPs in order to be more responsive;
- optimise the treatments used and take account of the particularities of each NPP;
- investigate alternative solutions to biocidal treatment;
- contribute to the epidemiological surveys carried out by InVS and AFSSET.

ASN duly noted the action plan proposed by EDF for controlling the maximum legionella concentration levels in the cooling systems. In this plan, which was revised following the AFSSET opinions and built around enhanced surveillance of the NPPs, EDF defines preventive and remedial measures to be implemented, while seeking to minimise the chemical discharges resulting from the treatment processes employed.

Since the summer of 2008, at the request of ASN, EDF has been taking steps to enhance the surveillance carried out on its NPPs. This approach should contribute to improved oversight of the NPPs and, together with improvements to the quality of the legionella surveillance process, should make the microbiological monitoring carried out by EDF more robust.

ASN observes that EDF is making considerable efforts to control the risks linked to the development of legionella in the circuits of the large cooling towers. The general approach undertaken by EDF concerns both control of the resources already available and a search for alternative solutions, as recommended by AFSSET.

ASN however considers that it is essential for the make-up water treatment solution to be explored by EDF. However, this does not exclude regular or large-scale biocidal treatment in the event of contamination by pathogenic micro-organisms.

The conclusions of the make-up water treatment feasibility studies and the development of alternative solutions should enable EDF in 2009 to fine-tune its overall strategy for treating legionella in the large cooling towers.

4 | 4 | 2 Prevention of accidental water pollution

Pursuant to the order of 31 December 1999, mentioned in point 2|2|1 of chapter 3, ASN in 2006 required that certain work be done to ensure the conformity of the NPPs, particularly the effluent tanks and their retention areas. This work was completed in 2007.

Following the July 2008 events in the BNIs operated by SOCATRI (in Tricastin) and by FBFC (in Romans-sur-Isère) respectively, ASN asked EDF to check the condition of all the retention systems that could contain toxic, radioactive, flammable, corrosive or explosive fluids and to carry out any necessary repairs as rapidly as possible. In response to this request, EDF implemented a verification programme that is scheduled to run until 31 December 2009.

4 | 4 | 3 Noise

With regard to noise pollution, the impact of the NPPs is regulated by the above-mentioned order of 31 December 1999. This order limits the noise caused by the NPPs, referred to as the “sound emergence”, in other words the difference between the ambient noise level when the NPP is operating and the residual noise level when the NPP is stopped. As an example, this difference should not exceed 3 dB (A) at night.

In 2001 and 2002, EDF carried out noise measurements on all its NPPs. The study showed that ten plants were in conformity while there were nonconformities at the nine other NPPs of Belleville-sur-Loire, Bugey, Chinon, Civaux, Dampierre-en-Burly, Golfech, Nogent-sur-Seine, Penly and Saint-Laurent-des-Eaux. The main noise sources identified were the cooling towers, the turbine halls, the BAN stacks and the transformers.

In response, EDF defined an overall treatment approach based on sound-proofing studies. For each noise source, partial or total sound-proofing techniques were examined. 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 therefore oriented its strategy along three main lines:
– reduction and if possible elimination of the main noise frequencies;
– priority given to industrial noise sources;
– whenever possible, no aggravation of the situation if the NPPs are modified.

Hydrocarbon releases into the Loire and Rhone rivers

Hydrocarbons were released into the environment on several occasions in 2008, leading to accidental pollution of the Loire by the Chinon NPP and of the Rhone by the Bugey NPP.

Concerning the Chinon NPP:
In early afternoon on 24 September 2008, maintenance on equipment in the non-nuclear part of the Chinon NPP led to a release into the Loire river of an estimated 10 m^3 of a mixture of oil and water, subsequently re-estimated at 3 m^3.

The maintenance work was on an oil separator used to separate oil and water in the non-radioactive effluents collected from the reactors 3 and 4 turbine halls. Following this operation, a malfunction (unavailability of the level sensor) which was not detected by the licensee, led to effluent overflow into the power plant's rainwater collection network and subsequent discharge of these effluents into the Loire.

At about 15 h 00 on 24 September, an eyewitness observed the presence of hydrocarbons in the Loire and notified EDF who, after investigation, stopped the equipment concerned about 30 minutes later.

The Orleans division, accompanied by the Bourgueil gendarmerie and the Director of the préfet's office, carried out an inspection on 25 September 2008, during which the non-radioactive nature of the pollution was confirmed. Furthermore, the inspectors observed that the closure devices installed to prevent accident effluent flow into the environment, did not function correctly. This constitutes a violation of Article 19 of the order of 31 December 1999 and the NPP's effluent discharge and water intake licence (order of 20 May 2003 amended by the order of 17 August 2005).

Concerning the Bugey NPP:
At about 10 h 00 on 19 November 2008, an emulsion was detected in the separator of the settler-oil remover in the Bugey NPP reactors 2 and 3 turbine hall. A high level in the settler triggers an alert lamp and shuts down water evacuation to the SEO network. The lamp failed to light and the automatic shut-off device remained open. The isolating valve was closed by hand. On the same day at 14 h 15, the gendarmerie notified the NPP of the presence of oil and emulsion in the Rhone river downstream of the NPP. The link with the settler-oil remover malfunction was confirmed by EDF after investigation.

The following measures were taken:
– isolation of the polluted SEO line;
– activation of the "non-PUI" crisis organisation from 15 h 30 to 20 h 10;
– drainage of the settler-oil remover and cleaning of the SEO line;
– determination of the nature of the oil and search for its origin;
– request for appraisal of the settler-oil remover.

About a hundred litres of oil from the turbine lubrication system would therefore seem to have been released.

In November 2008, ASN sent EDF a letter asking it to check all the oil removers and associated alarm systems in the NPPs and to learn the lessons from experience feedback from these events.

Furthermore, for NPPs with cooling towers or a river weir, EDF considered that the detrimental effect generated by the noise of falling water in these works is less than noise of an industrial nature.

In 2005, EDF conducted additional measurement campaigns and completed its studies.

In 2006, ASN concluded that EDF's overall approach was acceptable and that the emergence obtained on NPPs by including falling water type noises in the residual noise constitutes the performance indicator. ASN at the same time reviewed EDF's justification documents in order to adopt a stance on each of the NPPs identified as being non-compliant.

In 2008, EDF continued with validation of the intended modifications. The work should be launched on NPPs concerned in 2009. Once the work is completed, EDF will take acoustic measurements to check the effectiveness of the solutions implemented.

5 ASSESSMENT

5 | 1 ASN's general assessment of the past year

The following general assessment gives a summary of the various subjects covered by ASN's evaluation of EDF's head offices and the performance of its NPPs in terms of nuclear safety, radiation protection and the environment.

This evaluation is based on the results of checks carried out by ASN in 2008, particularly through inspections, oversight of reactor outages and analysis of how EDF handles significant events, as well as on the extent to which the inspectors are familiar with the NPPs they inspect. In 2008, ASN carried out 494 inspections in the NPPs in operation, in the EDF head office departments and at the EDF suppliers.

The general assessment represents the ASN viewpoint for the year 2008 and helps to guide ASN's regulatory actions in 2009.

5 | 1 | 1 Safety

Reactor operations

The operating documents, such as the normal operating rules, incident or accident operating rules and reactor maintenance rules, are on the whole clear and of good quality. These documents are generally well implemented on NPPs and give a good picture of the actual condition of the NPPs.

In 2008, ASN observed that EDF was firmly committed to improving the stringency of its operations, in particular through national action plans implemented locally on NPPs. It considers that the actions taken contribute to improving the stringency of operations but that EDF must continue to maintain the momentum of the progress already achieved. In this respect, ASN in 2008 observed anomalies in the preparation of maintenance work, in the surveillance of activities, in the management of temporary operating situations and of particular arrangements and resources and in the implementation of the operating procedures. ASN also observed a lack of stringency in the definition and adequacy of the post-maintenance qualification of equipment and cases in which the deadlines for periodic testing of equipment important for safety were exceeded.

ASN considers that NPPs are responsive to unforeseen operating events. They correctly implement the national reference documentation for incident or accident operations. However, in 2008, ASN observed a large number of anomalies in implementation of the national operating reference documentation in the event of local accident situations. ASN considers that the distribution of good practices among NPPs is satisfactory. It does however consider that more lessons could be learned from significant events on other NPPs.

In 2008, ASN noted EDF's efforts to improve its fire-fighting organisation, particularly the size of the operating teams dedicated to fire-fighting. ASN does however consider that EDF needs to check the adequacy of this organisation so that fire-fighting can be carried out at the same time as implementation of the operating rules in the event of an incident. ASN considers that EDF must continue its efforts, especially concerning management of sectoring, understanding and implementing fire instructions and compliance with response times.

ASN rates the way EDF handles emergency situations as satisfactory overall. Even if NPPs are correctly implementing an adequate staff training and qualification programme and regularly conduct training exercises, ASN considers that monitoring of training and operational communication between the control posts need to be improved. In 2008, ASN observed anomalies in the management of the equipment required for emergency situations.

Maintenance activities and subcontractors

ASN considers that the methods used by EDF to focus maintenance operations on equipment according to its safety, radiation protection and operational stakes are acceptable. ASN considers EDF to be strongly committed to this field.

ASN considers that the maintenance picture in the NPPs is on the whole good, but could be improved in certain areas, particularly with regard to implementation of the maintenance programmes for flammable or explosive fluid piping. It observed in 2008 that EDF has initiated action on NPPs to harmonise the maintenance reference documentation and control implementation of the new national reference documentation on this subject. These actions are accompanied by the creation of an organisation dedicated to oversight of the maintenance reference documentation.

In the field, ASN considers that the quality of maintenance preparation could be improved. In particular, EDF needs to improve the quality of the risk assessments and their assimilation by the staff concerned, and to boost surveillance of the implementation of remedial measures in the field. ASN also considers that EDF needs to improve management of spares and the availability of tooling. In 2008, ASN observed that the unavailability and nonconformity of certain spare parts led to longer maintenance intervals for equipment important for safety and non-compliance with the requirements of the maintenance reference documentation.

Most maintenance activities on NPPs are entrusted to contractors selected on the basis of a qualification and evaluation system. ASN considers that this system is implemented satisfactorily.

ASN is of the opinion that in 2008 EDF made progress in the surveillance of its contractors, even if it did observe occasional anomalies, frequently originating in a lack of the resources needed for surveillance of the work done. ASN noted the efforts made by EDF to improve maintenance preparation. It did however observe that insufficient preparation for the preliminaries clearance meetings, or even a complete absence of these meetings, often led to significant events.

On certain NPPs, ASN also noted that material resources are insufficient or inappropriate, which in some cases led to degraded contractor working conditions in terms of safety and radiation protection.

Equipment condition

Equipment maintenance and replacement programmes, the safety review process and correction of conformity anomalies identified contribute to keeping NPP equipment in a generally satisfactory condition.

ASN considers that the quality of the EDF operating documents for performance of the periodic tests is improving. In 2008, it did however observe non-compliance with deadlines for performance of periodic tests on equipment important for safety and a lack of stringency in the definition and adequacy of the post-maintenance qualification of the equipment. It considers that EDF needs to improve the preparation and oversight of these operations and enhance the competence of the preparation staff in order to minimise the persistent confusion between the objectives set during the periodic tests and those set during the post-maintenance qualification tests.

Pressure vessels

In ASN's opinion, EDF is still making progress in the management of pressure vessels. In 2008, ASN observed that EDF had made significant progress in pressure vessel documentation management. ASN does however feel that EDF must continue its efforts so that the inspection departments still to be audited are recognised in 2009. ASN considers that EDF must ensure that the recognised inspection departments are large enough to be able to perform their duties and must define exhaustive inspection plans. ASN also considers that EDF must improve the equipment hydrotest preparation conditions.

The first barrier

For ASN, the condition of the fuel cladding, which constitutes the first protection barrier in the reactors, is on the whole satisfactory.

Although EDF demonstrated an ability to respond rapidly to fuel rod tightness defects in 2007, ASN considers that following the identification of a new mechanism leading to tightness defects in 2008, EDF needs to maintain its efforts in searching for their causes and checking that the corrective action required of the fuel fabrication plants is sufficient.

With regard to fuel assembly handling operations, following the blockage of two assemblies in the upper internals of Tricastin reactor 2, ASN also considers that EDF must improve prevention and treatment of the migrating body problems that were the cause of this event.

The second barrier

Generally speaking, ASN considers that the current condition of the second barrier, consisting essentially of the primary system and the main secondary systems, is satisfactory but that known ageing and deterioration phenomena must be taken into account and covered by appropriate measures, primarily as part of the preparations for the third ten-yearly outages of the 900 MWe reactors.

ASN observed that new generic types of damage and anomalies have, especially since 2006, been appearing on the steam generators, for which the treatment methods used are in certain cases inadequately controlled. ASN notes that since the early 1990s, EDF has been implementing a replacement programme for the steam generators with the most severely damaged tube bundles. ASN also considers that in 2008, use of the steam generator chemical washing processes was improved.

Nonetheless, ASN is of the opinion that EDF must still improve the quality and preparation of the maintenance and spare parts files. On this subject, ASN feels that progress is needed for more stringent implementation of the decision of 31 January 2006 concerning the conditions for use and maintenance of primary and secondary system spares.

The third barrier

ASN considers that the condition of the third barrier, consisting of the reactor building containment, is satisfactory. ASN noted that the check on the tightness liners on the inner containments of the 1300 MWe and 1450 MWe reactors revealed no nonconformities in 2008. The results of the 1300 MWe reactor containment tests comply with the safety criteria. However, ASN observed a change in the leak rate from certain containments, despite the preventive tightness work carried out.

ASN considers that EDF must further pursue its efforts to improve the stringency of the operation of the third barrier, in particular with regard to implementation of the containment reference documentation and raising the awareness of the personnel on this subject.

5 | 1 | 2 Radiation protection

ASN considers that the progress momentum created by EDF over the past ten years to improve radiation protection in the NPPs has enabled a constant reduction in worker collective and individual doses to be achieved. It does however consider that EDF needs to sustain its efforts to improve the radiological cleanness of its NPPs.

ASN considers that the action plans implemented by EDF are consistent with the diagnosis of the situation and methodically implemented by NPPs. ASN in particular observes that the creation of an organisation for monitoring gamma radiography appliance exposure is beginning to bear fruit but it is of the opinion that this approach needs to be supported by increased competence and surveillance in the field.

ASN considers that EDF must continue with the efforts it has made to ensure that the radiation protection issues are shared by all the departments of a NPP and that a radiation protection culture is adopted by all the staff. It also considers that EDF must improve the risk and optimisation analyses for maintenance and the surveillance of radiation protection rules on the worksites, in particular the way controlled areas are designated and hot spots detected.

5 | 1 | 3 The environment

ASN considers that EDF's situation with regard to the environment is on the whole good but that it could still be improved in certain areas.

ASN observed that in 2008 EDF's involvement and the impetus of the actions initiated varied widely.

With regard to the files concerning effluent discharge, water intake and chemical washing of the steam generators, and despite considerable efforts made by EDF on these subjects, ASN still observes inadequacies and shortcomings which led to certain files being submitted incomplete. Although the environmental organisation of NPPs is clearly defined, anomalies were still observed in 2008 on a number of them, especially concerning the conformity of the NPPs, human factors and contractor surveillance.

ASN considers that EDF must also exercise vigilance concerning equipment issues, ICPEs and coolant fluids, particularly as these are not specific to the core business of a NPP licensee.

5 | 1 | 4 Personnel and organisation

ASN considers that the organisation defined by EDF is on the whole suitable for dealing appropriately with safety and radiation protection issues. The NPPs set themselves improvement targets in the various safety, radiation protection, environment and worker safety fields. However, in the field of safety, these objectives must be defined in a more realistic way. As in 2007, ASN nonetheless feels that progress is still needed in giving greater importance to non-radioactive discharges in the environmental objectives.

In the field of radiation protection, the stakes seem to be shared by all the departments concerned, but ASN considers that the contractors must be more closely involved in achieving the objectives. The EVEREST project, concerning radiological cleanness, leads the NPPs to set more ambitious targets.

ASN notes that efforts have been made in the NPP organisation of fire-fighting, especially through the eventual secondment by the Departmental Fire and Emergency Response Department (SDIS) of a professional fire-fighting officer on each NPP. It however considers that these efforts need to be increased by EDF.

The roles and responsibilities within the departments are defined in organisation notes but the distribution of the activities and responsibilities described in these notes is sometimes inappropriately adapted or not stringently implemented by the staff in the field.

As in 2007, breakdowns in communication or coordination between the departments led to anomalies.

ASN considers that the management of operating personnel skills and qualifications in NPPs is satisfactory. However, as in 2007, ASN considers that the staff training, in particular of the contractors, could be improved in the radiation protection and environment fields.

Manning levels are generally speaking appropriate. However, ASN considers that appropriate organisations must be put into place to strengthen the operating teams when faced with heavy workloads, especially during reactor outages, whether scheduled or unscheduled. The surveillance of the activities of the contractors is also a task for which the manning levels sometimes prove to be insufficient.

The actions taken as part of the “human performance “project, which aims to improve the reliability of the work done and the presence of managers in the field, are a source of progress for both maintenance and operation. ASN considers that these actions are all the more beneficial if the contractors are involved in them and the activities performed in favourable conditions.

ASN is of the opinion that the conditions in which operation and maintenance work is carried out is not always satisfactory, in particular owing to working environment conditions which could be improved and to inappropriate documents, insufficient hardware resources and protective equipment, in addition to a heavy workload or time pressure.

In 2008, ASN also observed a rise in the number of ergonomic defects. These defects concern documents, individual equipment, the fitting out and layout of certain premises. They more particularly concern operating activities and are the cause of anomalies.

ASN observed that working times were exceeded and that there was unfamiliarity with the safety rules and the risks, as well as excessively tight performance deadlines, sometimes to the detriment of working conditions. Maintenance activities performed during reactor outages are a good illustration of this point. ASN considers that the risks on the worksites, including for human safety, need to be identified and handled as of the preparation phase and the participants, including contractor staff, must be familiar with these risks and the associated compensatory measures.

5 | 1 | 5 Operating experience feedback

Generally speaking, the organisation put into place in the NPPs by the licensee to deal with operating experience feedback, allows satisfactory detection and identification of the events. ASN considers that NPPs are effectively incorporating national information and playing a proactive part in the exchanges. Analysis of these events by NPPs is generally of good quality. However, ASN considers that EDF must improve its identification of the causes of the events.

With regard to monitoring the performance of corrective action taken following the events, ASN considers that EDF must progress further, especially in verifying the implementation and long-term continuity of the operational corrective actions taken. The lack of corrective action following this operating experience feedback led to a number of anomalies in 2008 which could have been avoided, particularly the blockage of the fuel assemblies in the Tricastin 2 reactor.

5 | 2 Individual NPP assessments

The following assessment of EDF’s NPPs summarises ASN’s evaluation of the performance of each NPP with respect to safety, radiation protection and the environment. This evaluation is based on the results of controls carried out by ASN in 2008, particularly through inspections, oversight of reactor outages and analysis of how EDF handles significant events, as well as on the extent to which the inspectors are familiar with the NPPs they inspect.

It takes account of qualitative rather than quantitative data. It represents ASN’s view for 2008 and helps to guide ASN’s regulatory actions for 2009. However, it must be borne in mind that the level of safety of a NPP is not set in stone and can change from one year to the next.

The performance of the various power plants in terms of nuclear safety and radiation protection is expressed in relation to ASN’s general assessment of EDF.

Belleville-sur-Loire NPP
ASN considers that the Belleville-sur-Loire NPP is under-performing in terms of nuclear safety and environmental

protection, with respect to ASN's general assessment of EDF performance.

ASN feels that operation is insufficiently stringent. Although progress has been observed in detection of anomalies, progress is still needed in the way in which they are analysed and dealt with. Moreover, the large number of alignment, maintenance and operating problems, particularly during reactor outages, leads ASN to wonder as to the effectiveness of the action taken by the NPP since the 2006 in-depth inspection, with regard to the operating stringency of its NPP.

However, the NPP has progressed in the field of radiation protection, in particular by setting up an efficient organisation for preparation of radiographic inspections.

Finally, in 2008, ASN recorded significant environmental deviations and observed that the NPP was fragile in terms of surveillance and monitoring of NPPs liable to have an impact on the environment.

Blayais NPP

ASN considers that the nuclear safety and radiation protection performance of the Blayais NPP is on the whole in line with ASN's general assessment of EDF performance.

ASN considers that the NPP made progress in 2008 in improving the reliability of the control operations felt to be sensitive, thus reducing the number of reactor scrams and excursions from the reactor normal operating domains. It also considers that the NPP has progressed in the management and implementation of the radiographic inspection activities.

However, ASN feels that the NPP must progress further in terms of operating stringency, especially with regard to the preparation and performance of work during reactor outages. Finally, the NPP needs to tighten up surveillance of subcontracted radiation protection activities.

Bugey NPP

ASN considers that the Bugey NPP stands out with regard to nuclear safety performance and that its performance in the field of radiation protection is on the whole in line with ASN's general assessment of EDF performance.

ASN is of the opinion that the NPP offers an example of good maintenance management, particularly during reactor outages.

However, ASN considers that the NPP needs to make particular progress in the environmental field, as this year, a significant number of deviations originated in waste management and contractor surveillance.

The NPP must also continue its efforts to reduce the number of reactor scrams and improve the radiological cleanness of the worksites during the reactor outage periods.

Cattenom NPP

ASN considers that the nuclear safety and radiation protection performance of the Cattenom NPP is on the whole in line with ASN's general assessment of EDF performance.

In 2008, ASN noted that the NPP was still the example to be followed in terms of radiation protection and further improved the radiological cleanness of certain areas.

However, once again this year, ASN considers that the NPP needs to progress in the preparation and performance of maintenance work as well as in contractor surveillance.

With regard to environmental protection, ASN is of the opinion that the NPP must further boost its efforts to reduce its non-radioactive discharges into the environment. The studies initiated by EDF into controlling and reducing legionella concentrations in the cooling towers should in particular be completed in 2009.

Chinon NPP

ASN considers that the nuclear safety, radiation protection and environmental performance of the four nuclear reactors producing electricity on the Chinon NPP are on the whole in line with ASN's general assessment of EDF performance.

ASN observed considerable progress in the performance of maintenance work and routine operation. The level of anomaly detection was also improved. However, the number of deviations in implementation of the technical operating specifications and the number of significant containment events remains high.

The NPP must also remain vigilant in the radiation protection field, especially concerning the management of access to limited stay areas and dosimetric assessments. Finally, although environmental matters are dealt with satisfactorily, the pollution of the Loire river by hydrocarbons illustrates the need to tighten up the surveillance of the NPPs.

Chooz NPP

ASN considers that the Chooz B NPP stands out with regard to radiation protection performance and that nuclear safety performance is on the whole in line with ASN's general assessment of EDF performance.

ASN observed that the Chooz B NPP had made further progress in the field of pressure vessels as well as in implementing its human performance organisation.

ASN does however consider that the Chooz B NPP needs to improve management of access to regulated access areas and make progress in the environmental and NPP operation fields.

Civaux NPP

ASN considers that the Chooz B NPP stands out with regard to radiation protection performance and that nuclear safety performance is on the whole in line with ASN's general assessment of EDF performance.

ASN observes that the NPP has made progress in improving the reliability of the control operations felt to be sensitive, thus reducing the number of excursions from the normal reactor operating domain. However, ASN considers that the NPP must progress further in the stringency of its preparation and performance of the periodic tests.

ASN considers that reactor outage management is on the whole satisfactory. However, it feels that improvements are needed with regard to the integrity of the new fuel assemblies used.

ASN observes that the radiological cleanness of the NPP premises is among the best of the French plants in operation. The new approach allowing entry into controlled access areas wearing work overalls is beneficial in that it demands greater vigilance in keeping the NPPs clean.

Cruas-Meysse NPP

ASN considers that the Cruas-Meysse NPP is under-performing in terms of nuclear safety and that performance in the other fields is on the whole in line with ASN's general assessment of EDF performance.

ASN considers that operations on the Cruas-Meysse NPP are insufficiently stringent, despite the progress initiated on its NPPs by EDF. As in 2007, this year was marked by a large number of significant safety events, originating in non-compliance with technical operating specifications.

The succession of repetitive anomalies reveals the difficulties experienced by the NPP in operating the plant as well as in dealing collectively with anomalies and implementing a continuous improvement approach.

ASN considers that the steam generator chemical washing operations are satisfactory in terms of safety, security and the environment. However, this impression is somewhat offset by the formal notice served on the NPP by ASN concerning the condition and upkeep of the piping carrying hydrogen.

Dampierre-en-Burly NPP

ASN considers that the Dampierre-en-Burly NPP stands out with regard to stringent implementation of the safety requirements.

ASN also observed that the NPP's organisation enables unforeseen technical events to be managed in compliance with the basic safety rules. The dosimetry results obtained when replacing the steam generators of reactor 4 also confirmed the NPP's high level of radiation protection management.

With regard to conventional safety, the results have improved slightly, owing to the adoption of a more proactive safety management policy.

Fessenheim NPP

ASN considers that the Fessenheim NPP is under-performing in terms of operating stringency and that performance in the other fields is on the whole in line with ASN's general assessment of EDF performance.

In 2008, ASN observed that the steps taken by the NPP as part of its operating stringency action have not fully borne fruit. Updating of the reference documentation is practically complete and all staff have been trained in using it. The organisation manual is currently being revised in order to consolidate the progress achieved so far.

However, ASN considers that the adoption of the new operating stringency requirements by the field personnel could be improved. In 2008, ASN again observed anomalies with respect to compliance with technical or conventional safety instructions, in the notification and processing of deviations from the technical reference documentation and in the performance of maintenance operations.

Flamanville NPP

ASN considers that, as in 2007, the Flamanville NPP is under-performing in terms of stringency of operation and maintenance and that the performance of the NPP in the other fields is on the whole in line with ASN's general assessment of EDF performance.

The Flamanville NPP carried out two ten-yearly outages in 2008, with the reactor 1 ten-yearly outage involving a large number of technical problems and significant safety events.

ASN therefore observes that although the operating stringency plan implemented since February 2007 led to improvements in terms of organisation, the efforts made must be continued in order to improve the operating stringency of the NPP.

Golfech NPP

ASN considers that the nuclear safety and radiation protection performance of the Golfech NPP is on the whole in line with ASN's general assessment of EDF performance.

ASN considers that in relation to previous years, the NPP is under-performing in the field of operation and maintenance. ASN believes that in order to obtain the high level of results it is aiming for, the NPP will need to maintain its efforts to improve operating stringency, especially during reactor outages involving numerous maintenance activities, as is the case with maintenance outages.

Furthermore, even if operation of the nuclear pressure vessels is on the whole satisfactory, ASN considers that the NPP needs to demonstrate greater stringency in implementation of the regulations.

However, ASN observes that the step forward represented by access to controlled areas in work overalls is satisfactory because it demands greater vigilance in maintaining the level of radiological cleanness of the NPPs and premises.

Gravelines NPP

ASN considers that the nuclear safety, radiation protection and environmental performance of the Gravelines NPP is on the whole in line with ASN's general assessment of EDF performance, which is an improvement over 2007.

Following ASN's observation of a lack of operating stringency, an action plan was drafted by the NPP in the second half of 2007. ASN considers that in 2008, this plan led to improved safety results, especially in terms of operation, personnel support and contractor surveillance.

The NPP also satisfactorily initiated work on renovating the fire networks. The size of the NPP allows satisfactory organisation of the response to and management of emergency situations.

However, ASN considers that the NPP needs to make further progress in improving the reliability of maintenance work and the surveillance of activities involving explosive and chemical products.

Nogent-sur-Seine NPP

ASN considers that the nuclear safety and radiation protection performance of the Nogent-sur-Seine NPP is on the whole in line with ASN's general assessment of EDF performance.

ASN considers that the results on the Nogent-sur-Seine NPP are satisfactory in terms of maintenance, even if it feels that the NPP needs to improve its adoption of the new regulatory requirements concerning the notification of modifications on equipment important for safety.

ASN considers that the Nogent-sur-Seine NPP deals correctly with environmental protection matters. However, ASN believes that the NPP needs to make progress in identifying and dealing with coolant fluid leaks from the chiller units.

ASN is also of the opinion that the Nogent-sur-Seine NPP needs to improve in the fields of radiological cleanness and preparation for fire-fighting.

Paluel NPP

ASN considers that the Paluel NPP is under-performing in terms of operating stringency and maintenance and that performance in the other fields is on the whole in line with ASN's general assessment of EDF performance.

The Paluel NPP conducted the last of the second ten-yearly outages on its reactors in 2008, with no significant anomaly.

ASN noted the implementation of an operating stringency plan for the Paluel NPP in order to comply with the equipment maintenance, post-maintenance qualification and NPP operating stringency requirements. ASN considers that the main points of this plan adequately cover the areas for progress identified by ASN in recent years.

However, ASN considers that once again this year, the efforts made by the Paluel NPP in these areas need to be continued.

Penly NPP

ASN considers that the nuclear safety and radiation protection performance of the Penly NPP is on the whole in line with ASN's general assessment of EDF performance.

ASN considers that the NPP still stands out with regard to management presence in the field, the management being heavily involved in overseeing human performance. However, ASN believes that efforts are needed to improve the quality of the preparation and performance of maintenance operations and the objectivity and detachment of the control room operators.

Finally, ASN considers that the NPP needs to improve the quality of updating of its safety documentation and compliance with these safety requirements.

Saint-Alban NPP

ASN considers that the nuclear safety, radiation protection and environmental protection performance of the Saint Alban NPP is on the whole in line with ASN's general assessment of EDF performance.

ASN considers that the controls carried out on the main primary system and the containment of reactors 1 and 2 during the ten-yearly outages indicate that this equipment is in a satisfactory technical condition.

However, ASN believes that the NPP needs to exercise vigilance with regard to management of the administrative lockouts determining and guaranteeing the position of the devices contributing to the availability of the equipment important for safety.

Saint-Laurent-des-Eaux NPP
ASN considers that the nuclear safety and radiation protection performance of the two Saint-Laurent-des-Eaux reactors is on the whole in line with ASN's general assessment of EDF performance. Safety is a consideration for all parties involved on the NPP.

ASN observed significant progress in 2008, especially during reactor outages, in monitoring the post-maintenance qualification tests. The operating reference documentation would also seem to be better understood and implemented.

ASN however considers that a lack of communication between the maintenance and operating teams was the cause of a large number of anomalies in 2008. The NPP will also need to pay particular attention to managing reactor shutdown or restart transients, during the two reactor outages scheduled for 2009.

Tricastin NPP
ASN considers that the operational and radiation protection stringency of the Tricastin NPP is on the whole in line with ASN's general assessment of EDF performance.

ASN considers that the NPP must continue its efforts to bring down the number of events due to non-compliance with technical operating specifications. ASN also observes that reactor outages were often extended, leading to problems of personnel availability for performance of the scheduled maintenance programme.

ASN considers that following the fuel assemblies blockage event on reactor 2, the NPP needs to improve the sustainability of the remedial measures taken on the basis of operating experience feedback and foreign object detection in the vessel and it needs to implement effective monitoring of the positions of the fuel assemblies during reloading.

In terms of radiological cleanness, ASN observes that there are still a number of shortcomings.

However, ASN considers that the action plan undertaken by the NPP for renovation of the NPPs or the effluents treatment systems is contributing to improved environmental protection and should be continued.

6 OUTLOOK

In 2009, ASN work and regulatory actions concerning NPPs will follow the main orientations given below:

Regulation of the Flamanville EPR reactor
Following a favourable opinion from ASN, the Government signed the authorisation licence decree for the EPR reactor at Flamanville on 10 April 2007. The NPP construction began in 2007 and continued this year under ASN oversight. This oversight of construction, involving spot checks proportionate to the safety issues, will continue until the NPP receives commissioning authorisation.

At the same time, ASN will also be continuing with an early review of certain aspects of the commissioning application file, in particular the accident study methods and the NPP control principles.

Development of technical regulations consistent with European best practices
In 2009, ASN will continue to focus on bilateral and multilateral international cooperation in order to compare its practices with those of its foreign counterparts and to promote sharing between experts, in particular with regard to operating experience feedback on the design and construction of new reactors.

Following the January 2008 adoption by the seventeen member countries of WENRA of a finalised version of safety reference levels for the reactors in operation in Europe, ASN will in particular continue to concentrate on the new harmonisation work started by WENRA concerning the safety objectives for the new reactors.

With regard to the reference levels adopted by the European members of WENRA in 2008, ASN intends to make a proposal to the Government by 2010 for their transcription into a coherent set of regulatory (ministerial orders, ASN decisions) and other texts (ASN guides).

This short-term effort to develop regulations and to give a formal framework to French safety policy concerning power generating reactors also corresponds to ASN's aim of preparing for the possible arrival in France of a new NPP licensee. It cannot be ruled out that an operator other than the traditional public operator (EDF) could launch a new project in France. ASN has therefore started discussions with the Franco-Belgian SUEZ group, which already operates seven nuclear reactors in Belgium, through its subsidiary Electrabel. ASN will continue these exchanges with greater intensity in 2009.

Regulation of the NPPs in operation

ASN considers that the condition of EDF NPPs is satisfactory and that the operating methods applied – both maintenance programmes and operating rules – are appropriate. In the fields of radiation protection and environmental protection, ASN considers that EDF obtained results in 2008 that were on the whole satisfactory. However, ASN is of the opinion that the efforts made by EDF on NPPs in terms of operational stringency need to be continued and that the assimilation of experience feedback by NPPs needs to be consolidated. Following formal notice served on the Cruas-Meysse NPP, ASN will also check that EDF has taken the remedial steps necessary to ensure site conformity with the requirements of Article 16 of the order of 31 December 1999.

In 2009, ASN will check EDF compliance with its decision concerning control of the risk associated with transport and storage of explosive gases such as hydrogen. ASN will also ensure effective implementation on the NPPs of an improved fire-fighting action plan drafted by EDF.

The planned adoption by EDF of a new type of fuel management on the 1300 MWe reactors also led to an in-depth review of the safety of these reactors if this fuel management were to be used. ASN aims to conclude this review in 2009 and then issue requirements for the reactors that will be using this new management.

Safety reviews and operating lifetime

Through conformity reviews, a permanent search for anomalies by its engineering departments and the tests and checks carried out during the ten-yearly outages, EDF is attentive to the possibility of generic risks, which are inherent in a standardised population of NPPs. EDF takes advantage of this standardisation in making operating experience feedback between the reactors more efficient and effective. It is also important for EDF to continue to take steps to improve safety still further. To do this, the periodic safety reviews are key opportunities for working with ASN.

EDF also initiated a safety review of N4 reactors and will present its conclusions to ASN in 2009. Implementation of the modifications arising from this review is planned for the first ten-yearly outages of N4 reactors, which will start in 2009 and run until 2012.

The third ten-yearly outages on the 900 MWe reactors are scheduled to start in 2009, particularly on Fessenheim 1 and Tricastin 1. ASN considers this to be a fundamental step in obtaining a precise picture of the condition of the reactors and in analysing EDF's ability to continue to operate them. The assessment of generic aspects of the 900 MWe reactor safety review, on the occasion of their third ten-yearly outages, which was completed in 2008, will lead ASN to adopt a stance in 2009. Finally, following the third ten-yearly outages of the 900 MWe reactors, ASN will issue its opinion on the conformity of each NPP with the applicable safety requirements and the preconditions for their continued operation.