NUCLEAR POWER PLANTS

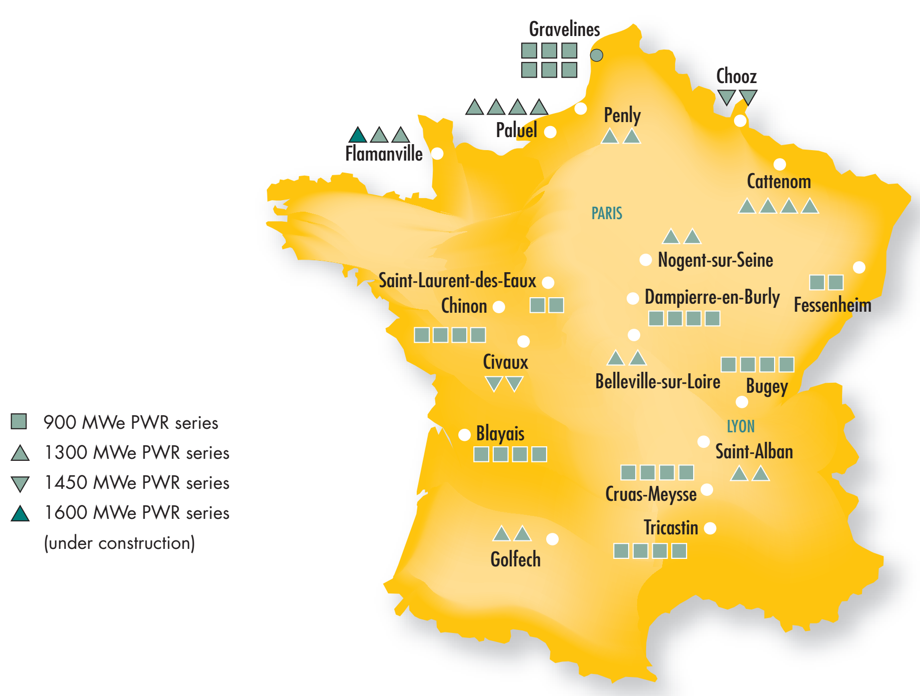
CHAPTER 12

Regulating nuclear power plants (NPPs) is ASN's historical mission. The reactors in these plants, used to produce electricity, lie at the heart of the nuclear industry in France. Many other nuclear installations 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. The reactors are currently operated by Électricité de France (EDF), which calls on the services of some 500 companies employing around 20,000 people for reactor maintenance. One particularity in France is the standardisation of plants, with a large number of technically similar reactors, justifying a generic presentation in this chapter.

Based on its extensive experience, ASN requires the highest of standards for regulating NPPs and adapts the standards continuously in the light of new knowledge. Ensuring control and regulation of the reactors, both operating currently and planned for the future, is the daily task of around 200 members of ASN staff working in the Nuclear Power Plant Department (DCN) and the Nuclear Pressure Equipment Department (DEP), and of the staff of the regional divisions. ASN also has the support of some 200 experts from the Institute for Radiation Protection and Nuclear Safety (IRSN). The ASN Commission meets regularly with the CEO of EDF to discuss nuclear safety and radiation protection issues. To be more effective, ASN has developed an integrated vision of control and regulation that covers not only the design of new installations, modifications, integration of feedback on events or complex maintenance problems but also, via the expertise its inspectors have built up, human and organisational factors of radiation protection and safety of workers, as well as the application of labour legislation. Lastly, ASN completes its judgement by examining the links between safety and competitiveness. This integrated approach allows ASN to develop a finer appreciation and decide on its position each year with regard to the current status of nuclear safety and radiation protection in NPPs.

In ASN's opinion, 2010 was a satisfactory year regarding safety and radiation protection in NPPs. However, ASN remains concerned about the impact of subcontracting of maintenance activities. Formal expression of the organisation of recourse to subcontracting for maintenance activities is satisfactory, as is the positive development observed in the area of radiation protection. Conversely, implementation of the subcontracting policy has some chronic shortcomings, relating especially to supervision of subcontracted activities and application of safety rules in a context of increasing requirements being placed on contracting companies. ASN has also pinpointed a lack of foresight in maintenance and equipment replacement programmes, especially where steam generators are concerned.

1 OVERVIEW OF NUCLEAR POWER PLANTS



Power reactor locations in France

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 series, 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 Le Blayais, Dampierre-en-Burly, Gravelines and Tricastin) and CP2 (ten reactors at Chinon, Cruas-Meysse and Saint-Laurent-des-Eaux).

The twenty 1,300 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 comprise four 1,450 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 have been introduced as design and construction of plants have developed.

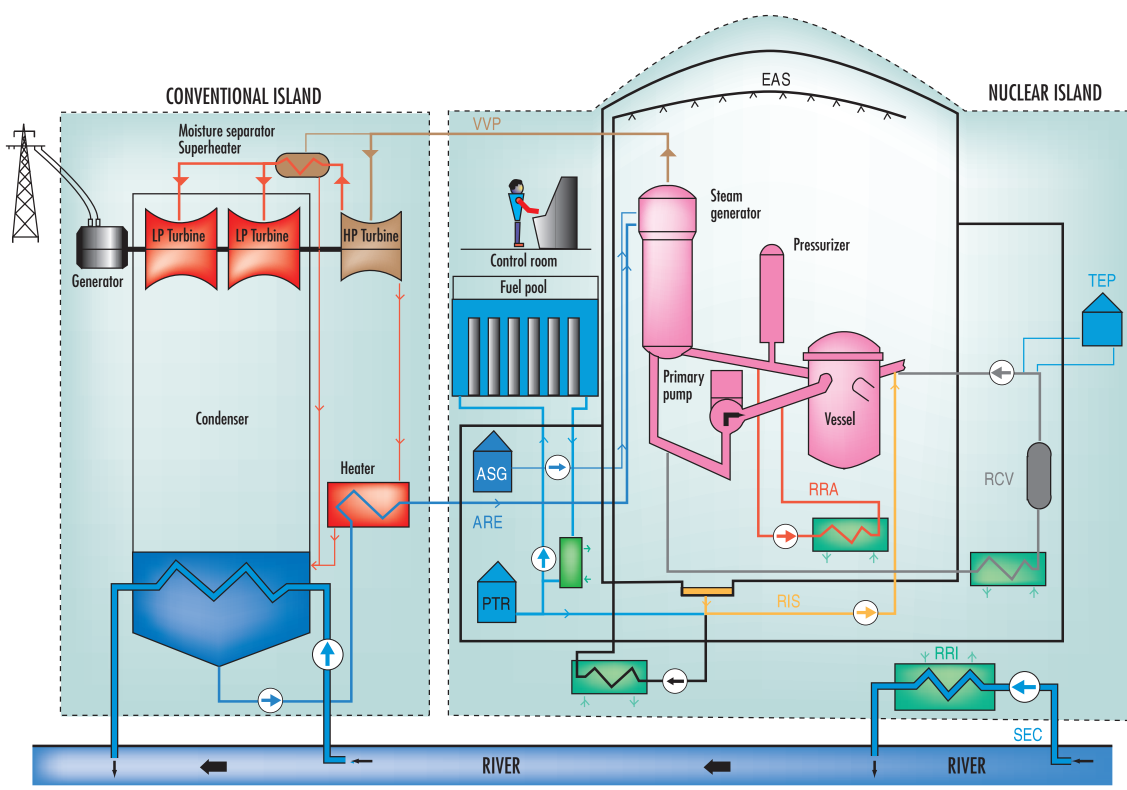
The CPY reactors differ from the Bugey and Fessenheim reactors (CP0) in building design and the addition of an intermediate cooling system between that used for containment spraying in the event of an accident and that containing heat sink water, along with more flexible operation.

The design of the 1,300 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 design of some systems.

The N4 reactors differ from the previous reactor series in the design of their steam generators (more compact) and of their primary coolant pumps, and in the computerisation of the control room.

Lastly, an EPR type 1,600 MWe pressurised water reactor is being built at Flamanville, a site already housing two 1,300 MWe reactors.



Block diagram of a pressurised water reactor

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, which they then transform into electricity. Conventional plants use the heat given off by the combustion of fossil fuels (fuel oil, coal, gas). Nuclear plants use 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 or a river or with an atmospheric cooling system.

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

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

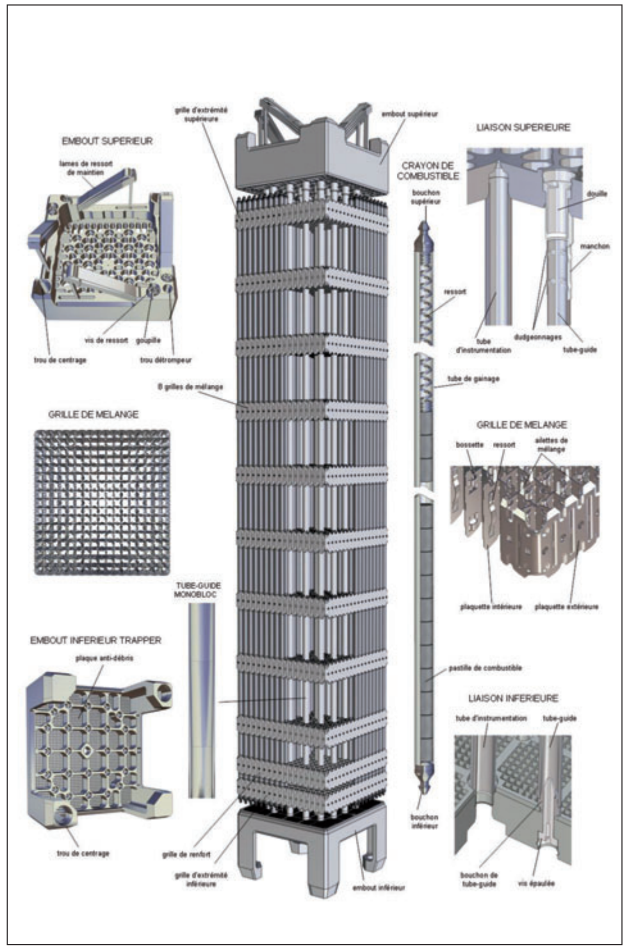
The conventional island equipment includes the turbine, the AC generator and the condenser. Some components of this equipment contribute to reactor safety.

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 analysis 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 building containment (see point 1|1|5) for the third barrier.

1|1|2 Core, fuel and fuel management

The reactor core consists of rods containing uranium oxide pellets or mixed uranium and plutonium oxides (fuel referred to as MOX) contained in metal tubes, referred to as the "cladding", grouped in fuel "assemblies". 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 through the top at a temperature of about 320°C.



Fuel assembly for a pressurised water reactor

At the beginning of the operating cycle, the core has a considerable energy reserve. This gradually falls during the cycle, as the fissile nuclei disappear. The chain reaction, and hence the reactor power, is controlled by:
– inserting control rod assemblies 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 electrical power to be produced. Falling of the control rod assemblies under the effects of gravity triggers automatic reactor trip;
– the concentration of boron (absorbing neutrons) in the primary system water is adjusted during operation as the fissile material in the fuel becomes depleted.

At the end of the cycle, 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 based fuels (UO2) with uranium 235 enrichment to a maximum of 4.5%. These fuels are fabricated in several plants in France and abroad, which belong to the fuel suppliers AREVA and WESTINGHOUSE;
– fuels consisting of a mixture of depleted uranium oxides and plutonium (MOX). The MOX fuel is produced by the AREVA MÉLOX plant. The initial plutonium content is limited to 8.65% (average per fuel assembly) and provides an energy

equivalence with UO2 fuel initially enriched to 3.7% Uranium 235. This fuel can be used in those 900 MWe reactors for which the decree authorising their creation (the DAC) authorises use of MOX: i.e. 22 reactors.

Fuel management is specific to each reactor series. It is characterised in particular 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 duration of an operating cycle;
– 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, for characterising the stresses to which the fuel is subjected.

1|1|3 Primary system 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 comprises cooling loops (three loops for a 900 MWe reactor, four loops for a 1,300 MWe, 1.450 MWe, or EPR reactor), the role of which is to extract the heat released in the core by circulating pressurised water, known as the primary water. Each loop, connected to the reactor vessel containing the core, comprises a circulating, or primary pump, and a steam generator (SG). 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 are heat exchangers which contain thousands of tubes through which the primary water circulates. These tubes are immersed in the water of the secondary system and boil it, without ever coming into contact with the primary water.

Each secondary system consists, principally, of a closed loop through which water runs in liquid form in one part and as steam in the other 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 then heated and sent back to the steam generators by the extraction pumps relayed by feed pumps through reheaters.

1|1|4 Cooling systems

The purpose of the cooling systems is to condense the steam coming from the secondary system turbine. To do this they comprise a condenser, a heat exchanger consisting of thousands of tubes in which cold water pumped from an outside source (river, sea) circulates. When the steam comes into contact with the tubes it condenses and can be returned in liquid form to the steam generators (see point 1|1|3).

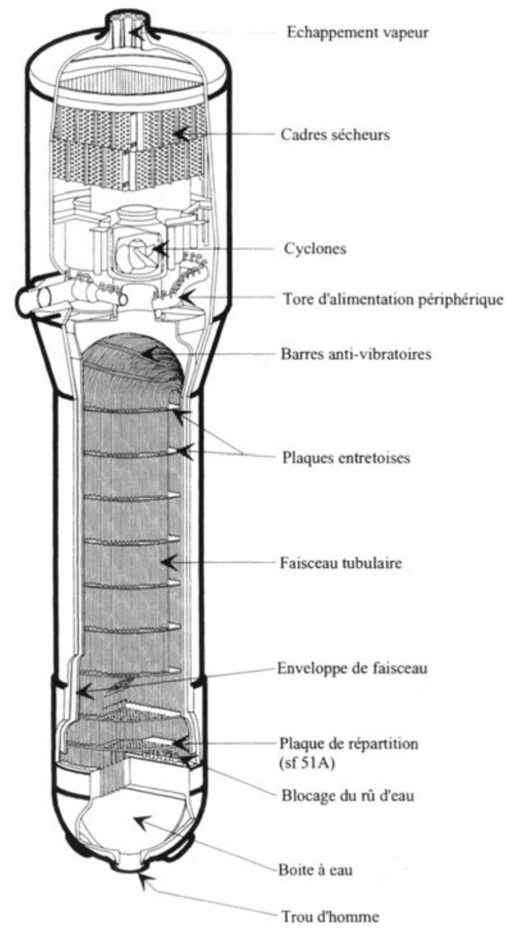
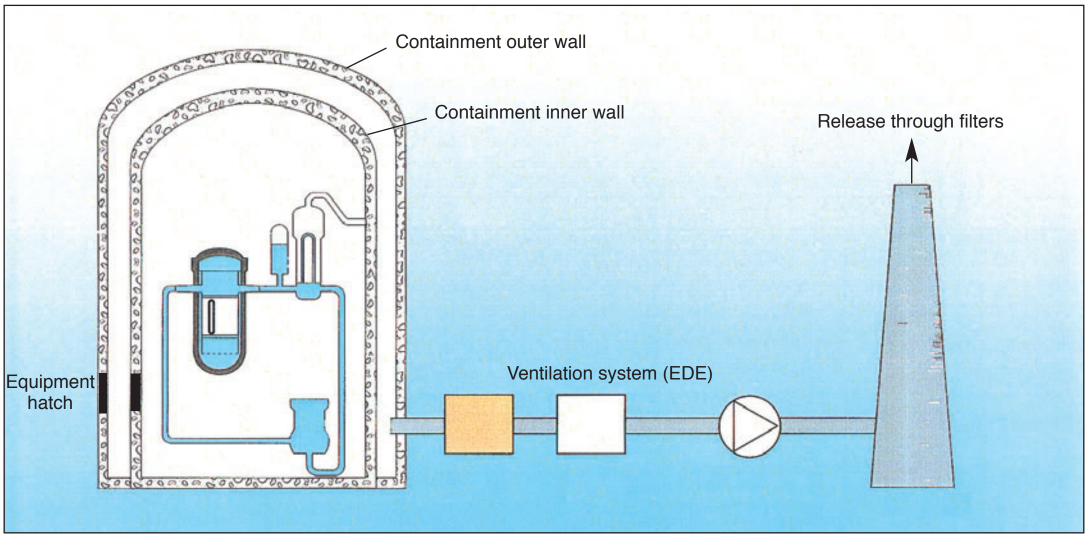


Diagram of a steam generator

Depending on the source of the cold water circulating in the condenser, the condensers are made either of brass (for river water) or of titanium or stainless steel (for seawater). Henceforth, during renovation, the brass condensers will be replaced by stainless steel or titanium ones, thereby reducing the amounts of metals released as a result of wear (brass being the source of releases of copper and zinc). However, unlike brass condensers, the renovated units do not constitute a toxic environment for micro-organisms and are therefore places where amoeba, potentially pathogenic micro-organisms, can develop. This can be prevented by use of biocides or other means of disinfection, e.g. ultraviolet radiation.

The cooling system water heated in the condenser is then discharged to the natural environment (open circuit) or, when the river flow is too low or heating too great in relation to the sensitivity of the environment, cooled in a cooling tower (closed or semi-closed circuit).

The conditions inside NPP's cooling towers are such that the potentially pathogenic micro-organism legionella can develop and can be propagated in the 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.).



Containment of a 1,300 MWe reactor

1|1|5 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 pre-stressed concrete and an outer wall made of reinforced concrete. Leaktightness is provided by the inner wall and the ventilation system (EDE) which, in the annular space between the walls, 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.

View of the concrete hull of a reactor building

1|1|6 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 basic safety functions: control of neutron reactivity, removal of heat from the primary system and fuel residual heat, containment of radioactive materials. This chiefly involves the Chemical and Volume Control system (RCV) and the Residual Heat Removal system (RRA).

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).

1|1|7 Other systems important for safety

The other systems necessary for reactor operation and important for safety 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 a nuclear power plant

1 | 2 | 1 EDF 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. This is the role of the Nuclear Engineering Department (DIN) and the engineering centres (for a detailed presentation, see *http://energie.edf.com*).

The operator, represented by the Nuclear Production Division (DPN) 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.

ASN contacts

As part of its national regulatory role, ASN maintains relations mainly with the DPN concerning the power plants in operation and with the DIN for new reactors. 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 fuels and fuel management are also discussed with a third division responsible for these questions: the Nuclear Fuels Division (DCN).

1 | 2 | 2 Close examination of 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 analysis report, 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 a malfunction 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 to maintain or restore the basic safety functions (reactivity control, cooling, containment of radioactive substances) and to 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 establishes the programme of physical tests for the reactor core that allow monitoring of the reactor in the restarting and operating phases.

Secondly, there are documents describing the in-service monitoring and maintenance actions required on the equipment. On the basis of the manufacturer's recommendations, EDF has 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.

Their implementation, particularly in the case of pressure equipment, requires use of non-destructive testing methods (radiography, ultrasound, eddy current, dye penetrant, etc.) entrusted to specially qualified staff.

Documentation conformity review by ASN inspectors during the in-depth inspection of Chooz – July 2010

1|2|3 Oversight of 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 is renewed. 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 verify 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 (ASR) 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 and hydrotest on the primary system, a reactor building containment test or incorporation of design changes decided on in the periodic safety reviews (see point 2|2|3).

These outages are scheduled and prepared 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:

Hydro-testing of reactor number 3 at Chinon – June 2009

– 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 outage, when the licensee presents its reactor outage report on the condition of the reactor and its readiness for restart. It is after this inspection that ASN will authorise restarting of the reactor;
– after criticality, the results of all tests carried out during the outage and after restart.

2 THE MAJOR NUCLEAR SAFETY AND RADIATION PROTECTION ISSUES

2|1 People, organisations, safety and competitiveness

Human and organisational factors make a determining contribution to the management of safety in nuclear installations that are operating, as well as to 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.

2|1|1 Workers

Between 800 and 2,000 men and women work to operate an NPP (the actual number varies depending on the number of reactors in the plant). This workforce is made up of EDF staff and permanent service providers breaking down into categories as shown below:
– plant operation: 50%;
– maintenance: 20%;
– administration and support staff: 30%.

In addition, large numbers of service providers and subcontractors participate in the maintenance and in specific operations scheduled during outages. The numbers of additional people involved during an outage can be from 300 to 2,700, depending on the type of outage.

These workers are exposed to the "conventional" risks that are common to all industries (working at height, ground level risks, etc.) as well as to the risks arising from use of ionising radiation.

In the case of a nuclear reactor, the exposure to ionising radiation is primarily due to activation products and, to a lesser

ASN inspection of the control room during the ten-yearly inspection of the Tricastin NPP – May 2009

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

degree, from fission products present in the fuel. All types of radiations are present (neutrons, α, β and γ) and the risk of exposure can be either external or internal. In practice, over 90% of the doses are from external exposure to β and γ radiation. Erosion and corrosion are the phenomena at the origin of this exposure, as they release materials or chemical species that are activated or that may be activated by a neutron flux and that are carried by the primary system.

These mechanisms notably account for the presence in the primary system of radio-isotopes of cobalt such as ^{58}Co and ^{60}Co, responsible for 80% of the doses received from external exposure.

Eighty per cent of the doses received by workers are related to maintenance operations performed during reactor outages. In 2010, the doses were distributed over a workforce of around 45,000 people, including EDF staff, service providers and subcontractors, as shown in graphics 4, 5 and 6, below (see point 6|1|2).

Monitoring of application of labour related legislation in NPPs is addressed in point 3|8.

2|1|2 Regulating human and organisational factors

For ASN, everything in the working situation and the organisation that has an influence on the actual activity of the individuals working in an installation such as a nuclear power plant constitutes what are called human and organisational factors (HOF). These factors are particularly concerned with anything that has to do with the organisation of work, the people involved (workforce, skills, motivation, etc.), the procedures, technical organisation and the working environment.

Whatever the level at which the activities to be carried out are specified, the situations actually encountered by individuals in the field vary constantly (equipment which does not react as expected, night-work, an inexperienced colleague, varying levels of urgency, labour disputes, etc.), obliging them to adapt how they work to attain the expected outcome at a cost (in terms of fatigue, stress, health, and so on) that is acceptable to them.

It is the licensee's responsibility to ensure that personnel are placed in satisfactory working conditions and have adequate means to adapt their procedures to the variability encountered in the working situations. Personnel must be able to carry out their duties correctly (safety, security, efficiency, quality) at an acceptable health cost, while deriving adequate benefit from it (feeling of a job well done, recognition of their peers and their hierarchy, development of new skills, and so on).

Inappropriate resources – for instance inadequate tools, cramped or poorly lit working environment, insufficient training or practice, poor design of man-machine interfaces, shortage of spare parts, professional teams destabilised by organisational change, under-manning or insufficient time allocated for tasks – can lead to risks. An operating situation in which performance is satisfactory but in which this was obtained at very high human cost to those involved is, therefore, a source of risk: only a slight variation in the context or change of a member of personnel can be enough to prevent the required performance level from being reached.

ASN regulation

ASN asks licensees to develop an explicit policy to address HOF, and to acquire the necessary resources for effective action and to take steps according to appropriate approaches and methodologies.

ASN regulation of HOF is based, mainly, 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

L'ASN considers that licensees must systematically implement an approach incorporating HOF into the following areas of activity:
– engineering activities during design of a new installation or modification of an existing one;
– activities carried out during the operation of existing NPPs throughout their period of operation;
– activities establishing feedback on reactors during their design, building and operation, and particularly analysis of causes of HOF and the lessons to be learned.

Implementation of the approach must be appropriate to the safety issues identified by the licensee. Adequate and appropriate resources and skills must be committed by the licensee at both national and local levels to allow implementation of the HOF approach.

2|1|3 Regulating the management of employment, skills, training and qualifications within EDF

Control of safety rests on the ability of the licensee's management system to ensure that the appropriate skills and adequate resources are available. Article 7 of the order of 10 August 1984 (see point 3|2|1 in Chapter 3) states categorically that *"only individuals with the required skills may be assigned to an activity affecting quality"*. 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.

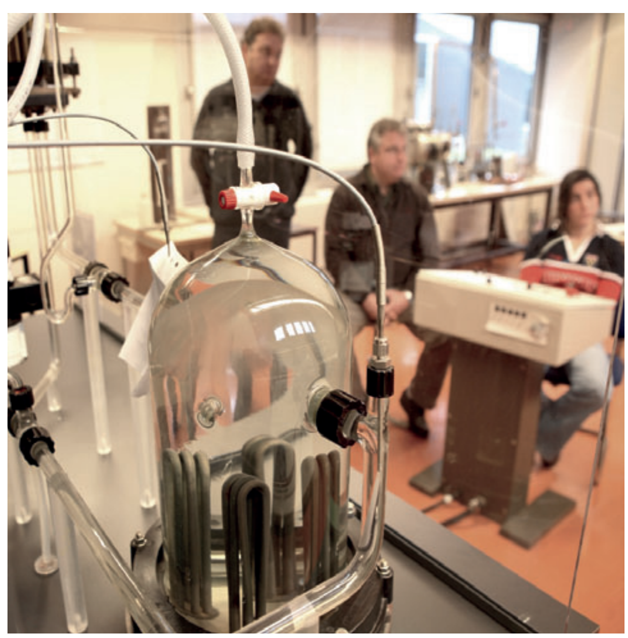
ASN regulation

Pursuant to the above-mentioned Article 7 of the order of 10 August 1984, ASN monitors the quality of the employment, skills, training and qualifications management system and its implementation 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.

2|1|4 Incorporating safety management into the general management system

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 organisation 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 and to develop and implement a system allowing the safety of its installation to be maintained and constantly improved. It is based on a process of continual safety improvement, incorporating:



Training session in the training site laboratory in the Paluel NPP

– 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 in their daily activities. Finally, it must be possible to compare them with the results achieved, to allow continual improvement and to ensure that safety progresses.

ASN regulation

The order of 10 August 1984 contains the requirements to be followed by the licensee to define, obtain and maintain the quality of its installation and the conditions for its operation. The requirements are mainly concerned with the organisation that the licensee, who has primary responsibility for safety in its installation, must put in place to ensure control of the activities affected by quality.

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.

Improving safety must be a permanent aim for management. During its inspections, ASN was able to assess the progress monitoring initiated by the sites, which is on the whole satisfactory. Improvements are needed in the traceability of this progress monitoring. It is also important for these measures to be clearly formulated and carried out at clearly defined intervals.

2 | 1 | 5 Monitoring the quality of subcontracted operations

A large proportion of reactor maintenance operations in France's NPPs is 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, ASN's role is to ensure that EDF exercises its responsibility for the safety of its installations, by implementing a quality approach, and in particular by monitoring the conditions under which subcontracting takes place. This approach is officially laid out in the "Progress and sustainable development charter" signed by EDF and its main service providers.

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. As a complement to this, EDF must ensure the quality of preparation of operations and monitor or arrange for monitoring of the activities performed by its contractors. It must also make use of feedback to continuously monitor contractors' capacity to retain their qualification.

ASN carries out inspections on the implementation of and compliance with EDF contractor monitoring requirements in the NPPs. As part of its oversight of the construction of the FA3 reactor, ASN also carries out inspections on this aspect within the various engineering departments in charge of the design studies (see point 2 | 4 | 2).

2 | 1 | 6 Safety and competitiveness

Act 2000-108 of 10 February 2000, on modernisation and development of public electricity service introduced in-depth change into the electricity market in France. The act stipulates EDF's public service obligation but also transposes a European directive on the internal electricity market into legislation, notably placing EDF in competition for generating and supply of electricity to industrial and private customers. Competition will increase under reform of the electricity market (Act 2010 -1 488 of 7 December 2010 on new organisation of the electricity market). EDF has opened its capital, with the French state retaining 84% of the shares.

The concern with cost control is today stressed more by the operator in its dealings with the ASN. Technical discussions with EDF clearly reflect a harder line with regard to economic feasibility, justification of certain demands and deadlines, and on the very short-term handling of some files during unit outages.

ASN regulation

To develop control and regulation in this context, ASN has developed tools for early identification of possible drift: developments in spending, purchases relating to improving of safety (maintenance and R&D), personnel management, development of safety and radiation protection indicators and changes in the licensee's organisation are the object of increased vigilance. Developments in spending indicate that EDF is continuing to invest in the maintenance of its assets and that the R&D effort remains satisfactory. In general, ASN's examination found no drift that was cause for concern. However, ASN will, in the future, continue to be attentive to the possible consequences of changes to EDF's organisation introduced by the company in order to achieve its economic targets.

ASN will also develop exchanges with its counterparts in other countries to work towards a harmonisation of requirements in the face of the increased international nature of licensees and of the coming competitive electricity market. Work by the Western European Nuclear Regulators' Association (WENRA) and the OECD's Nuclear Energy Agency, (NEA) and by the International Atomic Energy Agency (IAEA), in which ASN takes an active part, is contributing to this harmonisation (see Chapter 7).

Work meeting on a civil engineering worksite involving a team of contractors

2|1|7 Submitting certain operations to a system of internal authorisations

ASN has requested that EDF submit certain operations relating to operating of installations and considered as sensitive from the nuclear safety and radiation protection standpoint, to a system of stricter internal checks as planned in ASN decision 2008-DC-0106 of 11 July 2008 concerning the procedures for implementation of the internal authorisation system in BNIs. Internal authorisations systems were 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 nuclear safety improvements

2|2|1 Oversight of anomaly correction

Anomalies are detected in NPPs through the proactive measures taken by the licensee and the systematic checks required by ASN. EDF is cultivating a questioning attitude whereby it takes the initiative to look for anomalies. The root causes of anomalies may be diverse: design problems, errors during construction, discrepancies introduced during maintenance operations, degradation due to ageing, etc. ASN considers that regular inspections and searches for anomalies carried out continuously by licensees contribute to maintaining an acceptable level of safety.

Systematic verification: conformity checks

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 verifications can be supplemented by a programme of additional investigations designed to check parts of the installation which are not covered by a specific preventive maintenance programme.

"Real time" verification

The performance of periodic test and preventive maintenance programmes on the equipment and systems also helps identify anomalies. For example, routine field visits are an effective means of discovering faults.

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

ASN requires that anomalies with an impact on safety be corrected within a time-frame commensurate with their severity. 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 the result of the time needed to prepare for remediation in conditions of complete 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 Examination 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 NPPs. Criteria for such notification have been established in a document entitled "Guide to Notification Procedures and the Codification of Criteria Concerning Significant Events in terms of Safety, Radiation Protection or the Environment, applicable to BNIs and Radioactive Material Transport". Each significant event is therefore rated by ASN on the International Nuclear Events Scale (INES), which comprises eight levels from 0 to 7.

ASN carries out local and national examinations of all significant events reported (the report for 2010 figures in 6|1|5). 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. In 2011, the GPR met to examine the important events of the 2006–2008

TO BE NOTED IN 2010

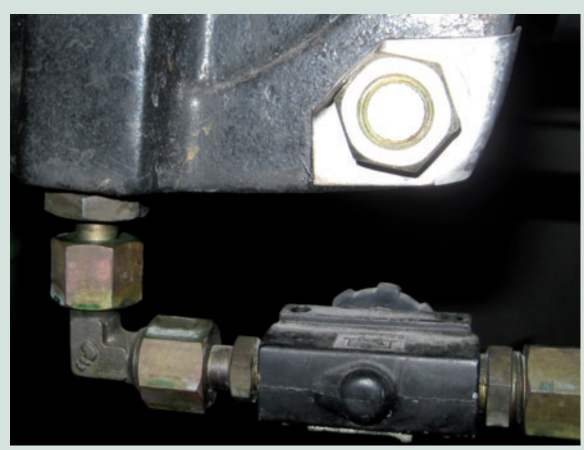
Incorrect tightening of threaded fasteners on seismically qualified valves

On 7 September, EDF notified ASN of an event relating to incorrect tightening of the threaded fasteners of seismically qualified valves in the Chooz and Civaux 1,450 MWe NPPs. The fault found was the absence of any tightening device or the presence of inappropriate devices on the fasteners of seismically qualified valves. Errors made during initial installation or during maintenance operations were the cause of these anomalies, which compromise the qualification of the valves.

Following this event, in 2009, EDF took action to perform checks and to re-establish compliance for the anomaly situations found on the Chooz and Civaux reactors. In February 2010, ASN asked EDF to introduce additional measures to prevent recurrence of these errors on the 1,450 MWe reactors and also on the 900 and 1,300 MWe reactors.

On 28 June 2010, EDF updated its incident reporting and established an inspection programme covering all of the reactors operated by EDF, to be applied from September 2010. EDF established the inspection programme on the basis of ranking of equipment to be checked as indicated by a safety analysis. EDF committed to return any fault observed to a state of compliance after these checks.

The anomaly was rated at level 1 on the INES.



Threaded fastener clamping devices: locking plate bent down on bolt period with a focus on events that were significant for radiation protection and for the environment, specific devices or means, post-maintenance testing operations, administrative sanctions, or anomalies encountered on steam generators.

2|2|3 Periodic safety reviews

Article 29 of the TSN Act requires that the licensees periodically conduct a safety review of their NPPs. This review is carried out every ten years. 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 of the installations, particularly by comparing the applicable requirements with those applied to more recent NPPs. The periodic safety review ends with transmission of the report required in III of article 29 of the TSN Act.

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) The conformity check: this consists in comparing the condition of the installation to the applicable safety requirements and regulations including, notably, the creation of authorisation decree and ASN's requirements. This step ensures that changes to the installation and its operation, as a result of modifications or ageing, comply with applicable regulations and do not compromise the installation's safety requirements. This ten-year conformity check does not relieve the licensee of its permanent obligation to guarantee the conformity of its installations.

2) The safety review: this aims to appraise the installation's safety and to improve it in terms of:
– French regulations, and the most recent safety objectives and practices, in France and abroad;
– operating experience feedback from the installation;
– operating experience feedback from other nuclear installations in France and abroad;
– lessons learned from other installations or equipment involving a risk.

Possibly after consulting the GPR, ASN may rule on the study topics envisaged by the licensee before the launch of the safety reassessment studies, during the phase known as the periodic safety review orientation phase.

3) Submission of a review report: subsequent to the above-mentioned steps, the licensee sends a review conclusions report to ASN. In this the licensee states its position on the regulatory conformity of its installation, and on the benefits of implementing or not implementing envisaged modifications intended to improve the installation's safety. The review report contains information provided for in Article 24 of Decree 2007-1557 of 2 November 2007, amended.

Implementation of the improvements emerging from the safety review

The ten-yearly outage is an ideal opportunity to make the modifications identified in the periodic safety review. To determine the ten-yearly outages calendar, EDF must take account of the hydrotesting schedule set by the nuclear pressure equipment regulations and the frequency of the periodic safety reviews as stipulated by the TSN Act. As an example, the third ten-yearly outages for 900 MWe reactors (reactors 1 in the Tricastin and Fessenheim plants) began in 2009, whereas the last 1,300 MWe reactors will undergo their second ten-yearly outage in 2011. The third ten-yearly outages for 1,300 MWe reactors will begin in 2015, with reactor 2 at the Paluel plant.

2|2|4 Approving modifications to equipment and operating rules

In accordance with the principle 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 of the incorporation of operating experience feedback.

Decree of 2 November 2007 clarified the requirements concerning implementation of changes by EDF and their review by ASN. In 2010, the equipment change notifications received by ASN were primarily aimed at improving reactor safety and correcting conformity anomalies.

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

2|3 Taking account of nuclear power plant (NPP) ageing

NPPs, like all industrial installations, are subject to ageing. ASN ensures 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 installations' lives.

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

The NPPs currently in operation in France were built over a relatively short period of time: forty-five reactors, representing 50,000 MWe, or three quarters of all the NPPs in service, were commissioned between 1979 and 1990 and thirteen reactors, representing a further 10,000 MWe, between 1990 and 2000. In December 2010, the average age of the reactors, calculated from the date of initial reactor criticality, was as follows:
– 29 years for the thirty-four 900 MWe reactors;
– 23 years for the twenty 1,300 MWe reactors;
– 13 years for the four 1,450 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 some reactor components was based on a pre-determined operating period, for reasons of the cost of their replacement but also, and indeed more so, because of the need for radiation protection of the workers who would have to carry out work. These components require close surveillance ensuring that their ageing rate is indeed as expected. This is in particular the case of the vessel, designed for a service life of at least 40 years (or the equivalent of 32 years of continuous operation at full power). The main mode of vessel ageing is irradiation, which modifies the mechanical properties of the steel of which it is made. The licensee must therefore take steps to predict changes to the vessel's properties and demonstrate that despite these changes, the equipment is able to withstand all normal or degraded operating situations it is likely to encounter, taking account of the safety margins set by the regulations. The reactor vessel is thus 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.

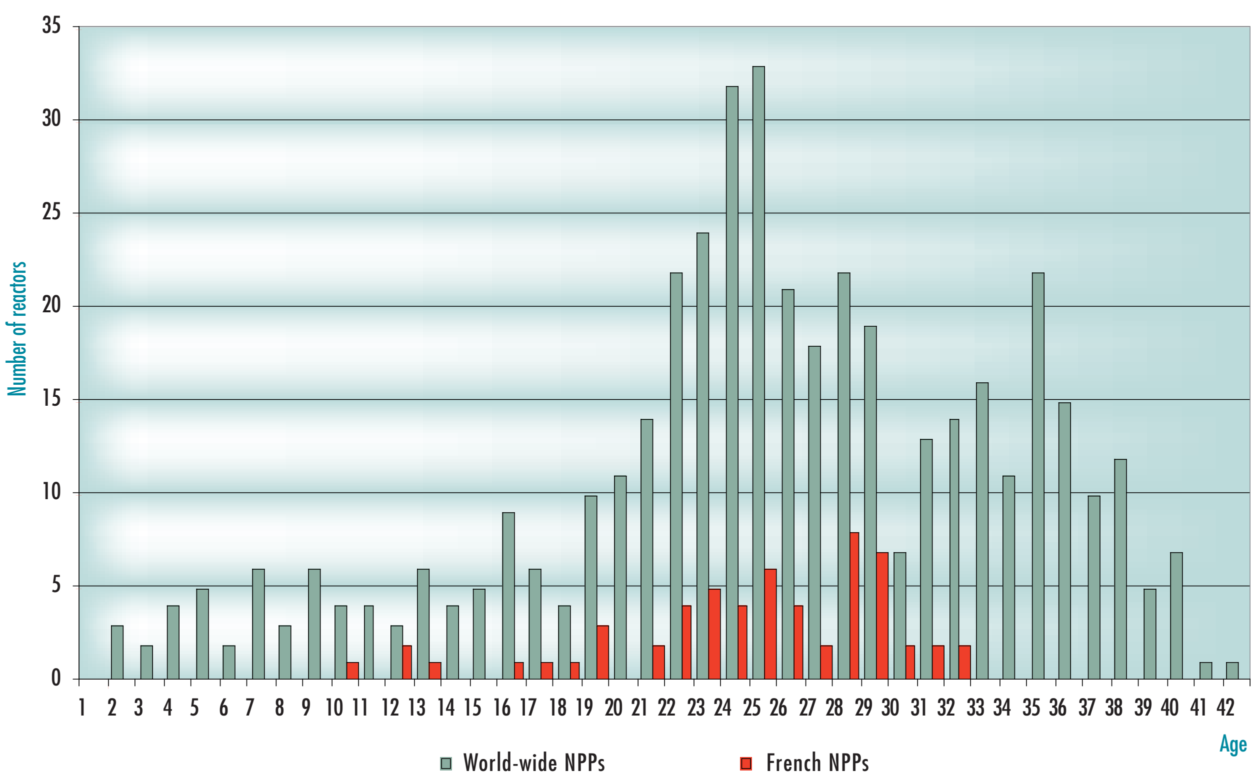
Equipment or component obsolescence

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, licensees must adopt a vigorous forward-looking policy.

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.

Graph 1: Breakdown by age of reactors in service worldwide (sources: IAEA, March 2009 and CEA, Elecnuc edition 2008)



2|3|3 How EDF manages equipment ageing

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

1) Consideration of ageing in 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 kinetics of known or presumed deterioration processes.

2) Surveillance and anticipation of ageing phenomena: ageing related phenomena other than those allowed for in design may occur during operation. The periodic surveillance and preventive maintenance programmes, the conformity checks (see point 2|2|1) or the operating experience feedback review (see point 2|2|2) aim to detect these phenomena.

3) Repair, modification or replacement of equipment likely to be affected: this type of action has to be planned in advance, given the procurement lead-times for new components, the operation preparation time, the risk of obsolescence of certain components and the loss of staff technical skills.

2|3|4 Examination of extended operation

From a strictly regulatory standpoint, in France there is no limit on the time that an NPP is authorised to operate. Conversely, Article 29 of the TSN Act requires licensees to review the safety of their installations every 10 years. Review – of which the primary purpose is to increase the level of safety of the installations – also provides the opportunity for in-depth examination of ageing of equipment (see point 2|2|3).

The periodic safety review concerning the third ten-yearly outages for the 900 MWe reactors

In the run-up to the 900 MWe reactors' third ten-yearly outages, ASN asked EDF to present a precise account of the ageing status of each reactor concerned and to demonstrate the possibility of continuing with operation beyond 30 years in satisfactory safety conditions. EDF has drawn up a programme of work concerning management of the ageing of its 900 MWe reactors. In July 2009, ASN issued a position statement on the generic aspects of continued operation of the 900 MWe reactors until 40 years after first criticality. ASN has not identified any element that would compromise EDF's ability to control the safety of the 900 MWe reactors over that period. ASN also considers that the new safety requirements presented in the generic safety analysis report for the 900 MWe reactors and the installation modifications envisaged by EDF are such as to maintain and improve the overall safety level of these reactors. However, this generic assessment does not take account of any specific features of individual reactors. ASN will therefore rule at a later date on the individual ability of each reactor to continue to operate, notably on the basis of the results of the verifications carried out during the reactor conformity check as part of the third ten-yearly outage and on the evaluation in the reactor's safety review report. On 4 November 2010, ASN pronounced on the conformity of reactor 1 in the Tricastin NPP with regard to the applicable safety requirements, and on the conditions for its continued operation for a period of up to 40 years, after the third ten-yearly outage. As an example, EDF has implemented modifications to the design of this reactor in order to reduce radiocative releases to the environment in the case of rapid draining of the spent fuel pit where the spent fuel assemblies are stored before their removal from the plant. Modification was focused on the system measuring the water level in the spent fuel pit and on the PLC controlling the cooling water pumps.

The periodic safety review concerning the second ten-yearly outages for the 1,300 MWe reactors

In 2006, subsequent to the safety review, ASN declared itself to be in favour of continued operation of the 1,300 MWe reactors up to their third ten-yearly outage. The changes arising from this safety review will be implemented by 2014. In 2010, the Belleville 1 and Nogent 2 reactors incorporated the changes following their second ten-yearly outage safety review.

The periodic safety review concerning the third ten-yearly outages for the 1,300 MWe reactors

In 2010, ASN established the outline for the safety review associated with the third ten-yearly outages for the 1,300 MWe reactors. Reactor 2 in the Paluel NPP will be the first to be subject to a third ten-yearly outage, in 2015. ASN will ensure that this periodic safety review, the first to have been prepared after the TSN Act, is in strict compliance with the requirements of the Act.

The periodic safety review concerning the first ten-yearly outage for the 1,450 MWe reactors

In 2008, ASN ruled on the orientation of the first periodic safety review for the 1,450 MW reactors, which in particular concerns the level 1 probabilistic safety studies and the hazards studies. In 2010, the modifications resulting from the safety review concerning its first ten-yearly outage were implemented on the Chooz B1 reactor.

Issues surrounding continued reactor operation

In the future, the reactors operating at present will run alongside reactors of the EPR type or their equivalent, designed for a significantly higher level of safety. This raises the question of the acceptability of continued operation of reactors beyond 40 years when there is an available technology that is safer. Two objectives are therefore imperative. First, a re-evaluation of the safety level in the light of that required of EPR type reactors or their equivalent is necessary, with proposals to bring about significant and relevant improvements to the reactors. R&D work in France and elsewhere is already indicating orientations that could lead to answers, and improvements that would provide significant reductions in radioactive releases in case of severe accident are being studied. Second, strict compliance of the reactors with the applicable regulations must be demonstrated. At the same time, ageing and obsolescence of the equipment will have to be managed. Where these two points are concerned, ASN expects far-reaching proposals from the licensee. With a view to a request for continued operation beyond 40 years, ASN has referred the matter to the GPR which will meet at the end of 2011 to establish the safety requirements for reactors at their fourth ten-yearly outage.

2|4 The Flamanville 3 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 1,600 MWe EPR type reactor on the Flamanville NPP, which already houses two 1,300 MWe reactors.

The EPR reactor is a pressurised water reactor based on an "evolution" in design in relation to 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, subsequent to the inquiry 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 Flamanville 3 reactor in September 2007. The first pouring of concrete for the buildings in the nuclear island began in December 2007. The civil engineering work has since continued. Installation of the first components (tanks, pipes, , electrical cables and cabinets, etc) began in 2010. In parallel with the construction work on the Flamanville site, manufacture of the pressure equipment, in particular that of the primary system (vessel, pressuriser, pumps, valves, pipes, etc.) and secondary system (steam generators, valves, pipes, etc.) is in progress in the manufacturers' facilities. In the summer of 2010, EDF announced that it was planning commissioning of Flamanville 3 in 2013.

2|4|1 The steps up to commissioning

Pursuant to the decree of 2 November 2007 (see point 3|1|3 of chapter 3), introducing nuclear fuel into the perimeter of the NPP and subsequent start-up, require authorisation by ASN. 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.

In anticipation of the sending of the complete commissioning request file, ASN, with IRSN, has undertaken an advance review of:
– the technical references necessary for demonstration of safety and for finalising of the detailed reactor design;
– the detailed design of some systems that are important for safety presented in the safety report;
– certain elements forming part of or guiding compilation of the commissioning request file.

ASN inspection of the EPR site at Flamanville

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

Advance review of required documents

In 2010, ASN and IRSN continued with reviews started in 2009, essentially of the future general operating rules. To date review has concerned the doctrines for drafting of technical and operating specifications and for periodic testing, the operating rules in case of incident or accident, and the principles of organisation and human and technical resources planned by EDF for operation of the Flamanville 3 reactor. Reviews have also been undertaken on radiation protection for workers and on the internal emergency response plan.

2|4|2 Construction oversight in 2010

For ASN there are numerous construction oversight issues relating to the Flamanville 3 reactor. They concern:
– ensuring that construction supervision complies with the new regulatory framework established 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, in addition to the usual means (inspections, etc.), ASN has established requirements for the DAC application concerning the design and construction of Flamanville 3 and for the operation of the Flamanville 1 and 2 reactors located close to the construction site. The principles and procedures for oversight of the EPR reactor construction cover 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 relating to construction activities on the nearby BNIs (Flamanville 1 and 2 reactors) and for the environment. As the subject is a nuclear power reactor, ASN is also responsible for occupational health and safety inspection duties on the construction site. In addition, ASN oversees the manufacture of pressure equipment that will form part of the primary and secondary systems and of the nuclear steam supply system. ASN action in this field in 2010 is described in point 5|1.

Oversight of nuclear pressure equipment manufacture

Nuclear pressure equipment comprises the components of a nuclear installation subjected to pressure, which can give rise to


View of the concrete formwork of the EPR spent fuel pools – August 2010


Overview of the EPR construction site – August 2010

radioactive releases if they fail (vessel, piping, steam generators, etc.), or to accidents. Manufacture of these items is regulated by the order of 12 December 2005 which adds extra safety, quality and radiation protection requirements to the regulatory requirements applicable to the manufacture of conventional pressure equipment (decree of 13 December 1999). ASN considers that the quality of nuclear pressure equipment has to be exemplary, because it determines the safety of nuclear installations. Within this framework, ASN or inspecting organisations accredited by it, evaluate compliance with regulatory requirements for each item of pressure equipment for the EPR reactor.

Oversight by ASN and its accredited organisations comes into play at different stages of design and manufacture of nuclear pressure equipment. It takes the form of examination of the technical documentation for each item of equipment and of inspections in the manufacturers' facilities as well as those of their suppliers and subcontractors. The manufacturer must also demonstrate its ability to control possible risks of variation in quality of materials arising from, for example, the complexity of manufacturing operations.

2 | 4 | 3 Cooperation with foreign nuclear regulators


Installation of a steam generator supply tank on the EPR site – December 2010

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

Bilateral relations

ASN enjoys close relations with foreign nuclear regulators in order to share previous and current experience of authorisation procedures and regulation of the construction of new reactors. In 2010, ASN and IRSN participated in bilateral meetings on these subjects with a number of foreign nuclear safety regulators: Finland, US, Switzerland, China.

Given the EPR reactor construction projects at Olkiluoto, in Finland and Flamanville, in France, ASN and IRSN have maintained enhanced cooperation with the Finnish nuclear regulator (STUK) since 2004. In 2010, this enhanced cooperation took the form of a technical meeting and visit to the Olkiluoto 3 construction site, with an agenda focusing on civil engineering and mechanical assembly.

Regular discussions between STUK and ASN also take place in order to share experience of nuclear pressure equipment manufacturing.

As nuclear installations are also be constructed in the US, exchanges with the American regulator, NRC, also took place in 2010, on the subject of oversight of construction of nuclear installations. For example, NRC's construction inspectors were able to observe an ASN inspection of the Flamanville 3 construction site.

Towards multinational cooperation

Some international bodies such as the NEA and WENRA also provide opportunities for exchanges on practices and lessons drawn from overseeing reactor construction.

In this context, ASN participated in the work outlined below, as a member of working groups set up to foster international cooperation in the area of evaluation of reactor design (Multinational Design Evaluation Programme, [MDEP], see Chapter 7 point 2 | 4):
– five themed meetings were held in 2010 with member countries of the MDEP group, focusing on the evaluation of the detailed design of the EPR. IRSN also took part. The meetings addressed radiation protection, severe accidents, instrumentation and

ASN participation in the IRRS (Integrated Regulatory Review Service) at the United States NRC (Nuclear Regulatory Commission)

ASN participation at the IAEA Consultancy Meeting held in Vienna (Austria) from 29 June to 2 July 2010

control, probabilistic safety studies, accident and transient condition monitoring. The plenary group also met twice, in May and November. The latest of these meetings was held in China;
– two meetings of the MDEP group on technical codes and standards were held in 2010;
– two meetings of the MDEP group on inspection practices and suppliers were held in 2010.

At the end of September, ASN also participated in a meeting of the WENRA working group on inspection practices and in working meetings on 9–10 November 2010, after which the WENRA members established their position on the safety objectives for new nuclear reactors (see Chapter 7, point 2|1|5).

Furthermore, in addition to the work on the EPR, a database was set up under the NEA framework recording the anomalies and discrepancies observed in recent or ongoing construction. For ASN, these international exchanges are one of the driving forces behind the harmonisation of safety requirements and regulatory practices.

TO BE NOTED IN 2010

Outcomes of enhanced cooperation between ASN and STUK

Finland was the first country to undertake the construction of an EPR. It was therefore natural for ASN and STUK to initiate enhanced cooperation. This enhanced bilateral cooperation is intended to strengthen the conclusions of the technical reviews conducted in each country on identical subjects and to share information on the difficulties encountered in overseeing detailed design, construction or manufacture. While there are sometimes differences in the ways in which the two countries address the subjects and oversee construction, the fact remains that the difficulties encountered are the same, in terms of design, construction and manufacture.

Accordingly, a meeting is organised between STUK and ASN every sixth months, with the participation of IRSN. Held by turns in France and in Finland, the meetings are organised in two stages: after technical discussions, the "visitors" act as observers to an inspection carried out on the construction site by their counterparts.

The meetings also provide the opportunity to benefit from the experience gained by each of the countries. For instance, the technical inspection of the containment metal liner welds appeared relevant to ASN which subsequently asked EDF to establish a new weld inspection programme on the basis of the Finnish practice.

Additional occasional meetings are also held as a complement to these events. Organised on a case-by-case basis, they focus on a particular technical theme. This was the case in 2010 for discussion of containment and of the quality of manufacture of some items of pressure equipment. It was these exchanges that led the two regulators to conduct a joint inspection of AREVA NP at one of the supplier's facilities (the FIVES NORDON company, Nancy, France (see point 5|1).

Lastly, it should be emphasised that the enhanced cooperation between ASN and STUK has led licensees and manufacturers to institute the organisation necessary for exchanges in order to share their operating feedback and to attempt to anticipate possible difficulties.

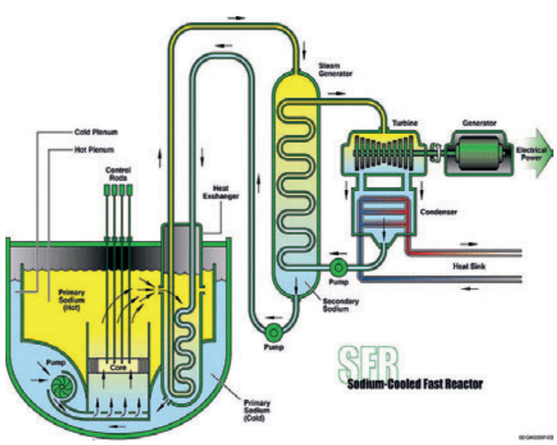
2 | 5 The reactors of the future: initiating discussions on generation IV safety

The French Alternative Energies and Atomic Energy Commission (CEA), in partnership with EDF has, since 2000, been involved in looking at the development of the fourth generation of nuclear reactors[1] ("GEN IV"), notably within the framework of the Generation IV International Forum (GIF). The forum was initiated in 2000 by the US Department of Energy and brings together 13 members that include research and industrial organisations from the nuclear countries around the world. The aim of the forum is to pool R&D work and to keep open the choice of possibilities for industrial development from amongst the following six selected technologies:

- SFR: sodium cooled fast reactor;
- GFR: gas cooled fast reactor;
- HTR/VHTR : gas cooled high temperature (850°C) and very high temperature (1,000°C) fast reactors;
- LFR: lead cooled fast reactor;
- MSR: molten salt reactor;
- SCWR: supercritical water reactor.

For those promoting them, the main issue for fourth generation reactors is to ensure the sustainable development of nuclear energy by making better use of resources, by minimising waste (ability to "burn" plutonium and to produce it from uranium 238, ability to transmute minor actinides such as americium and curium) and by offering better risk control regarding safety, proliferation and terrorism. There is a wide consensus on these objectives amongst GIF's members. Industrial development of fourth generation reactors in France is envisaged for the 2040–2060 period. It will require prior creation of a prototype, for which the planned commissioning date is set at 2020 by the Act of 28 June 2006 on the sustainable management of radioactive materials and waste.

In 2010, CEA undertook studies for a prototype SFR, under the ASTRID project. For CEA, this project forms part of the preparation of fourth generation reactors. CEA also informed ASN that its was maintaining its R&D activities on gas cooled fast reactors with a view to the development in a European context of a low-power experimental reactor (50–100 MWth) that will not generate electricity (the ALLEGRO project). The commissioning of this experimental reactor may be envisaged for 2025-2030.



Schematic of a sodium-cooled fast reactor

With this both medium- and long-term view, ASN wishes, at a stage well upstream of the regulatory procedure, to track the development of fourth generation reactors by French industrial concerns and the associated safety concerns – as was the case for the EPR – so as to be in a position, at the appropriate time, to establish the safety objectives for these future reactors. During meetings in 2010, ASN also indicated to the French stakeholders in the project its expectations regarding the framework to be established for exchanges for examination concerning the safety aspects of this project, and regarding the first documents required to begin technical discussions. These documents, forwarded at the end of 2009 and in 2010 by the French project stakeholders, relate to:

- the justification of the choice of technology selected for development in France;
- national and international operating experience feedback on the SFR reactors.

In 2011, ASN plans to obtain the GPR's opinion on these documents. In particular, the feedback must allow identification of the areas of research and development that warrant follow up or the improvements that would need to be made to installations if SFR reactors were to be operated again in France.

While it is perfectly legitimate to expect improved safety of fourth generation reactors in comparison with current ones, ASN nonetheless feels that it is premature to attempt now to fix safety objectives for reactors that will become commercially viable in several decades. Although the initial considerations within this framework are on the safety outlook for those SFR reactors highlighted by the CEA for its industrial prototype project, ASN wishes, in parallel, to maintain a watching brief on safety for the other types of reactors so as to, at this stage, maintain an open debate, especially with its foreign counterparts, on the safety objectives for the next generation of industrially produced reactors.

2 | 6 Reliance on nuclear safety and radiation protection research

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, especially concerning severe accidents, 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

1. "4th generation" reactors in opposition to the reactors currently available to renew the installed base of so-called "3rd generation" reactors (this name itself being in opposition to the present installed base of second generation reactors, e.g. in France, the pressurised water reactors (PWR) that succeeded the gas-graphite reactors of the first generation).

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 increase the pertinence of its demands. 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 their 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. There are a number of driving forces behind research into nuclear safety and radiation protection, whether technological aspects or human and organisational factors:
– new reactor projects: the research work launched for the EPR reactor and that associated with the design of the fourth generation reactors, 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 installations: for example, EDF's wish to improve nuclear fuel performance has, in particular, generated work on uranium oxide ceramics, fuel assembly cladding materials and 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 operation of the existing plants has initiated research into the ageing of materials and the evolution of structures and components, particularly the performance of the concrete containments and the properties of steel under the effects of irradiation;
– benefiting from feedback on events: research into the risks of flooding or modelling of movements of oil slicks that could affect NPP operation are worthy of note in this regard.

ASN is aware of the high stakes involved in being familiar with the latest research findings and has set up an organisation to more precisely identify its requirements. ASN thus identified the main subjects of interest, which would require greater investment.

3 NPP SAFETY

3|1 Operation and control

3|1|1 Operation under normal conditions: ensuring compliance with general operating rules and authorising changes to documents

Changing technical operating specifications (STE)

Chapter III of the general operating rules (GOR) contains technical reactor operating specifications (STE) (see point 1|2|2).

EDF may be required to modify the STEs to take account of its operating experience feedback, improve the safety of its installations, improve economic performance or incorporate the consequences of equipment modifications. Moreover, 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 these modifications and may approve them, possibly subject to implementation of complementary 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 report produced by EDF. EDF is thus 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.

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 Examination of incident or accident operating rules

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,

ASN inspection of the control room during the ten-yearly inspection of the Tricastin NPP – May 2009

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 GOR. Implementation or modification of these documents must be notified to ASN.

ASN examines the modifications of these operating rules and, notably, approves application of the files relating to reactor safety review. Some modifications to the APE procedures are the result of equipment modifications that will be incorporated during the ten-yearly outages, while others are the result of operating experience feedback or a response to ASN requests for improved safety.

To prepare the review of the commissioning application for the Flamanville EPR, the principles of operation in incident or accident conditions, which will be contained in the general operating rules relative to a safety incident or accident, will be subject to advance review.

Regular inspections are organised on the subject of incident and accident operation. During these inspections, particular attention is paid to examination of management of the operating documents of Chapter VI of the GOR, to management of special equipment used for accident operation and to training of operating staff.

Reactor operation in severe accident situations

If the reactor cannot be brought to a stable condition after an incident or accident and the scenario resulting from a series of failures leads to core deterioration, the reactor is said to be entering a severe accident situation. In such a, highly hypothetical, situation, various steps are taken to allow the operators, supported by emergency teams, to preserve the containment so as to minimise the consequences of the accident. The emergency teams may in particular use the severe accident management guide (GIAG).

3 | 2 Maintenance and testing

3 | 2 | 1 Regulating maintenance practices

ASN considers that maintenance policy is an essential line of defence in preventing the occurrence of anomalies and in maintaining the conformity of an installation with its safety requirements. Since the mid-1990s, EDF has been implementing a policy to reduce the volume of maintenance. 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 make changes to its organisation and adopt new maintenance methods. 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 consequences.

Furthermore, taking advantage of nuclear reactor standardisation, EDF is deploying the "pilot equipment" maintenance 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 in NPPs. The GPR held a meeting on this subject on 27 March 2008. On the basis of this review, ASN considers that the methods for optimisation of programmes for maintenance of equipment important for safety are acceptable. Giving precedence to equipment monitoring, these methods reduce the risks relating to operations on equipment and limit the dose received by operators. However, ASN has reminded EDF that the methods may lead to failure to detect a new or unforeseen fault, and has therefore asked EDF to underpin their dissemination by maintaining systematic periodic inspections for certain items of equipment. ASN has also reminded EDF of the necessity of questioning the validity of the pilot equipment approach in the event of discovery of deterioration or in case of repairs that could call into question the uniformity of a family of equipment.

ASN also reminded EDF that the use of these maintenance methods for pressure equipment 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 and thus only concern areas in which no known deterioration is likely. ASN has also strictly defined the conditions for the use of such an approach, stressing the fact that this monitoring would need to be extended if a defect were to be discovered.

In 2010, EDF announced to ASN its intention to move in the near future towards a new maintenance doctrine, the AP913. This methodology was developed in 2001 by the Institute of Nuclear Power Operations (INPO) working with American licensees. ASN will follow the introduction of this new doctrine closely.

3 | 2 | 2 Examining the qualification of scientific applications

The scientific applications contributing to the safety cases are subject to the requirements of the order of 10 August 1984. 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 2010, 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.

3 | 2 | 3 Guaranteeing the use of efficient control 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 system equipment must, before they are used, undergo qualification by an entity of proven competence and independence. This entity, the Qualification Commission, has been accredited by the COFRAC since 2001; it is to request renewal of its accreditation before May 2011. The role of the commission is to assess the

Ultrasonic inspection of a weld joint

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. 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 tests. The licensees are granted transitional periods of varying lengths for implementation of their respective programmes.

To date, 90 applications have been qualified by the in-service inspection programmes. New applications are in progress to meet new needs, especially for the Flamanville 3 reactor for which 41 applications are to be qualified. In order to reduce dosimetry, ultrasound applications are preferred to radiography.

3|2|4 Authorising periodic test programmes

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 GOR.

ASN is called on regularly to decide on declarations of modification of periodic test programmes and carries out review of design of periodic tests for the EPR.

3|3 Fuel

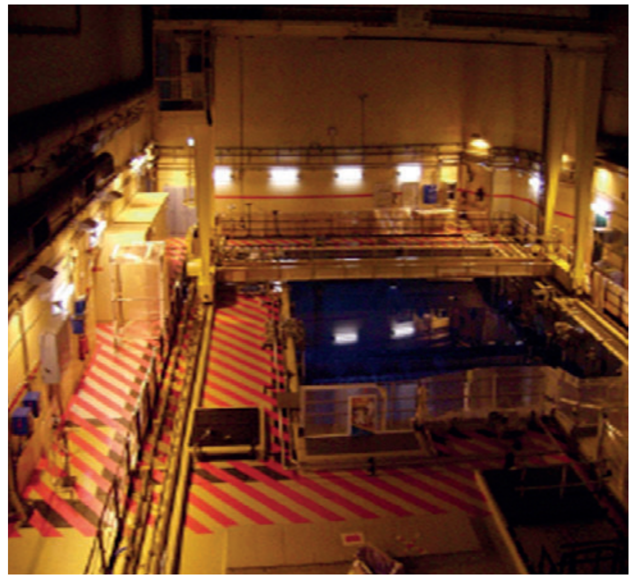
3|3|1 Controlling in-pile fuel management changes

In order to enhance the availability and performance of reactors in operation, EDF, together with the nuclear fuel industry, researches and develops improvements to fuels and their use in the reactor; this is known as "fuel management" (for more information on this concept, see point 1|1|2).

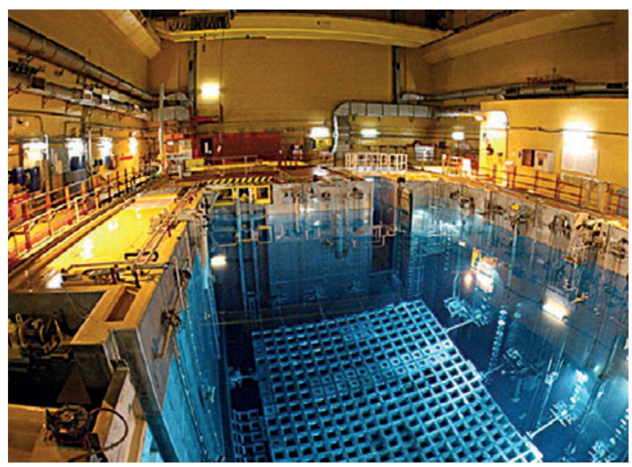
ASN ensures that each new mode of fuel management is the subject of a specific safety case for the reactors concerned, based on the specific characteristics of the new fuel management. When a change in the fuel or its management model leads to EDF revising an accident study method, this requires prior review and cannot be implemented without ASN approval. Since 2007, the adoption of new fuel management requires a decision from ASN containing implementation requirements.

3|3|2 Monitoring fuel integrity in the reactor

Fuel behaviour is an essential element of the safety case for the core in normal or accident condition operation and its reliability is of prime importance. The leaktightness of the fuel rods, of which there are several tens of thousands in each core and which constitute the first confinement barrier, are therefore the subject of particular attention. During normal operation, leaktightness is monitored by EDF by means of continuous measurement of the activity of radioelements in the primary system. Increase in activity beyond pre-determined threshold levels is an indication of loss of leaktightness of the fuel assemblies. Such faults appeared, notably, in fuel assemblies made from M5 alloy (see box). If the activity level becomes too high, application of the GOR leads to reactor shutdown before the end of the normal cycle. ASN has required of EDF that it search for and identify the assemblies containing leaking rods when unloading the core, and that EDF forbid their reloading. These assemblies may be repaired by replacement of the leaking rods before being re-used.



Marking out of a foreign body exclusion zone around the spent fuel assembly storage pool in Paluel



Spent fuel pool

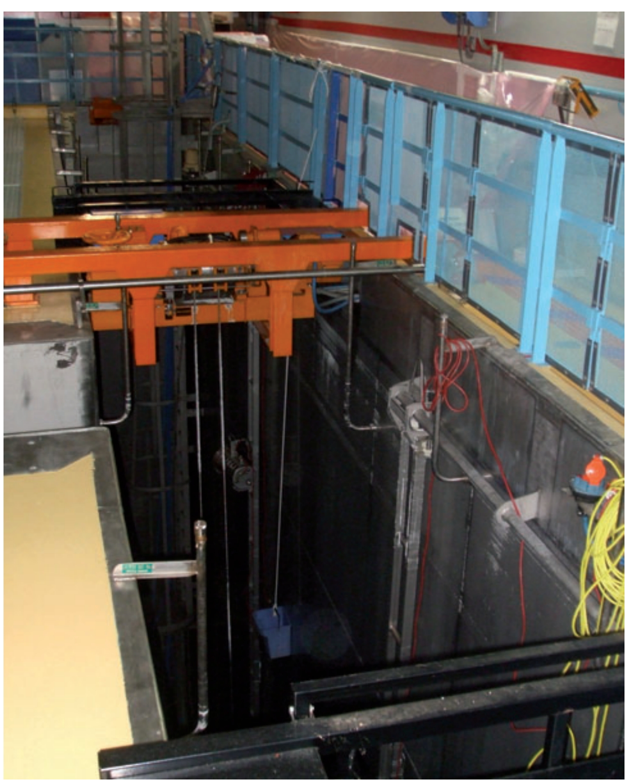
ASN also ensures that EDF analyse the causes of leaks and that it, notably, should implement examinations of leaking rods to determine the cause of the failure and to remedy this as soon as possible. Failure may be due to an inadequacy in design in relation to the loads actually sustained or to the presence of foreign bodies in the primary system damaging the cladding. Preventive and remedial actions may therefore affect the design of assemblies or their manufacture, or the reactor operating conditions. Furthermore, the conditions of handling of assemblies, the loading and unloading of the core and the prevention of foreign bodies in the systems and pits are also the subject of operating requirements, some of which contribute to the safety case and with which EDF's compliance is verified by ASN. ASN also conducts inspections to ensure that EDF carries out adequate monitoring of fuel assembly suppliers in order to guarantee that assembly design and manufacture comply with the rules established. Lastly, ASN calls on the GPR periodically for information drawn from operating feedback on fuel.

3 | 4 In-depth oversight of 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 3 | 6.

3 | 4 | 1 Monitoring and inspection of systems

ASN makes sure that the licensee carries out appropriate monitoring and maintenance of the main primary and secondary systems. To do this, the licensee draws up monitoring programmes which are submitted to ASN. After reviewing these documents, ASN can submit requests. The licensee is required to take account of these requests. In addition to these documentary reviews, ASN carries out thematic inspections on equipment maintenance, primarily during the reactor outages. ASN also examines the inspection results transmitted at the end of each outage. In addition to the monitoring carried out on its systems by the licensee during each outage, ASN checks the good condition of this equipment every ten years, on the occasion of periodic post-maintenance testing. Periodic post-maintenance testing comprises three distinct phases: inspection of the equipment, involving numerous non-destructive tests, pressurised hydrotesting and verification of the good condition and correct operation of the over-pressure protection accessories. Post-maintenance testing of the primary system is performed during the ten-yearly outages. In 2010, six main primary systems underwent periodic post-maintenance testing: on the Belleville 1, Chinon B4, Nogent 2, Tricastin 2, Bugey 2 and Chooz B1 reactors.



View of a fuel assembly handling device

3 | 4 | 2 Monitoring of nickel-based alloy zones

Several parts of pressurised water reactors are made from nickel-based alloy, for example the steam generator (SG) tubes and partition plates as well as vessel penetration tubes. However, in reactor operating conditions, one of the alloys used, Inconel 600, has proved to be susceptible to stress corrosion. This 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 monitoring 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. To date, the volumetric examination of the vessel penetration tubes in 600 alloy has not shown any signs of stress corrosion.

Piping verification by the ASN inspector during hydro-testing of the reactor coolant system (Cattenom)

TO BE NOTED IN 2010

M5 alloy fuel assemblies

The reactors currently using fuel with M5 alloy cladding are the four 1,450 MWe reactors, the 900 MWe reactors used for Parité MOX fuel management (for MOX fuel assemblies only) and three 1,300 MWe reactors.

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 have since showed no signs of tightness defects at the welds concerned by these improvements. However, other losses of tightness along cladding have been attributed to the abnormal presence of small chips of M5 produced under the fuel assembly springs. Initial remedial measures have been taken to limit the creation of these chips; other actions are being developed or are in the process of implementation. Tightness defects were again detected in some reactors containing M5 fuel assemblies. ASN has asked EDF to no longer employ assemblies with M5 cladding in its reactors.

Inspections of the SG partition plates in 2010, initiated after detection in 2004 of cracks thought to be caused by stress corrosion, yielded no new indication of cracking and showed no significant variation in the indications monitored. In addition the SGs are the subject of a major replacement programme (see point 3|4|4).

3|4|3 Checking reactor vessel strength

The reactor 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 accurate 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 this component is not included in the safety studies; this is one of the reasons why all steps must be taken, right from the design stages, to ensure its strength throughout the reactor's operational life.

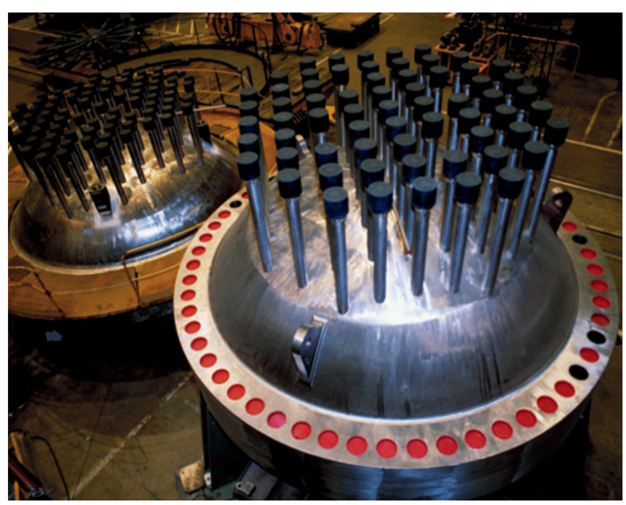
In normal operation, the vessel deteriorates slowly, under the effect of the neutrons resulting from the core fission reaction, which embrittles the metal. This embrittlement makes the vessel particularly sensitive to pressurised thermal shocks or to sudden pressure surges when cold. This sensitivity is also aggravated when defects are present, which is the case of some of the 900 MWe reactor vessels that have 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 programme was introduced to monitor the effects of irradiation: test specimens of the same metal as the reactor vessel were placed inside the reactor. Some of these are removed regularly 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 specimen capsules located near the core receive more neutrons than the metal of the reactor vessel;
– periodic checks verify that there are no defects or, in the case of vessels containing manufacturing defects, check that they are not getting worse.

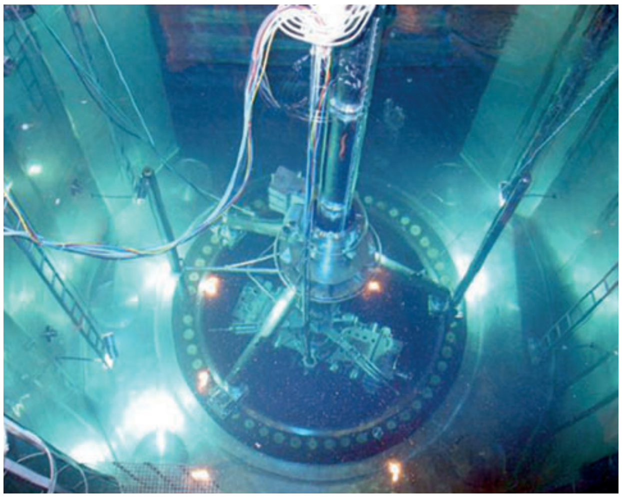
ASN carries out regular examination of the documents on the vessels' in-service behaviour forwarded to it by EDF, so as to ensure that the demonstration provided by EDF regarding vessel in-service behaviour is sufficiently conservative and that it complies with regulations. This file was presented to the advisory committee for nuclear pressure equipment in June 2010, and allowed ASN to establish its position on the conditions of operation of vessels beyond 30 years.

3|4|4 Monitoring steam generator maintenance and replacement

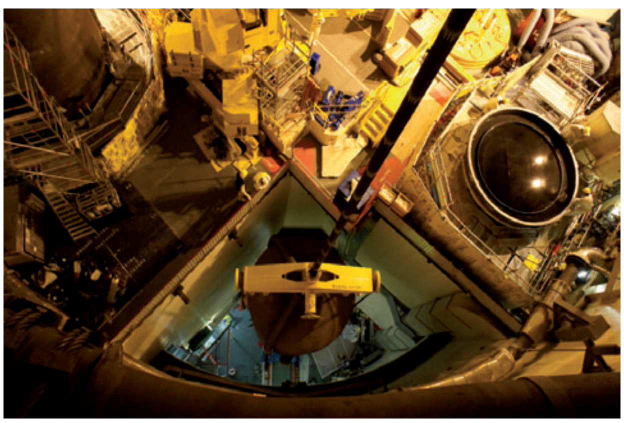
The steam generators are exchangers of heat between the water of the primary system and that of the secondary system. The exchange surface consists of a tube bundle comprising from 3,500 to 5,600 tubes, depending on the model. These tubes contain the primary system water and exchange heat while preventing any contact between the primary and secondary fluids.



Vessel closure head during manufacture (AREVA)



Vessel in-service inspection machine during an inspection



Replacement of a steam generator at the Blayais NPP in 2009

Integrity of the steam generator tube bundles is a major safety issue, since deterioration of a bundle can cause leaks from the primary to the secondary system. Furthermore, a break in one of the bundle tubes (SGTB) would lead to bypassing of the reactor containment, which is the third confinement barrier. Steam generator tubes are subject to several types of deterioration such as corrosion or wear.

The steam generators are the subject of a special in-service monitoring programme, established by EDF, reviewed periodically and examined by ASN. After inspection, tubes that are too badly damaged are plugged to remove them from service.

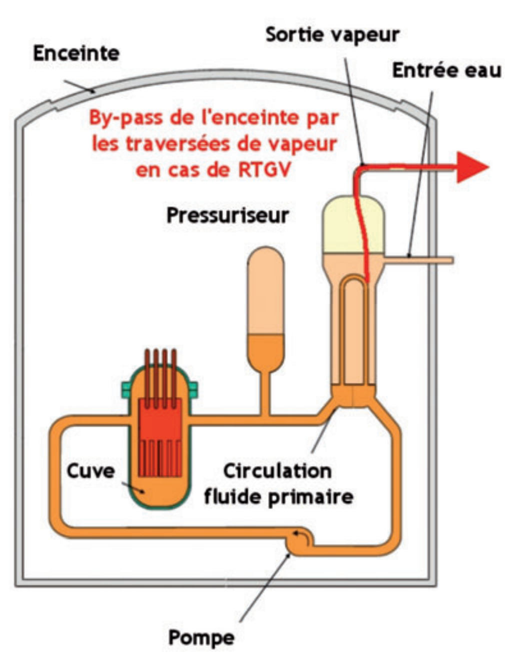
Since the early 1990s, EDF has been conducting a replacement programme for steam generators with the most heavily damaged tube bundles. This programme will continue at the rate of one reactor a year. At the end of 2010, six of the thirty-four 900 MWe reactors will still be equipped with steam generators containing tube bundles made of non-heat-treated Inconel 600 type nickel-based alloy (600 MA), which are the most affected by stress corrosion (see point 3|4|2).

3|5 Checking containment conformity

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 in the inner containment.

The results of the ten-yearly outage tests for the 900 MWe reactor containments have so far shown leak rates that comply with

Installation of equipment during chemical cleaning of a steam generator



Bypassing of the concrete containment in the event of an SG tube rupture accident

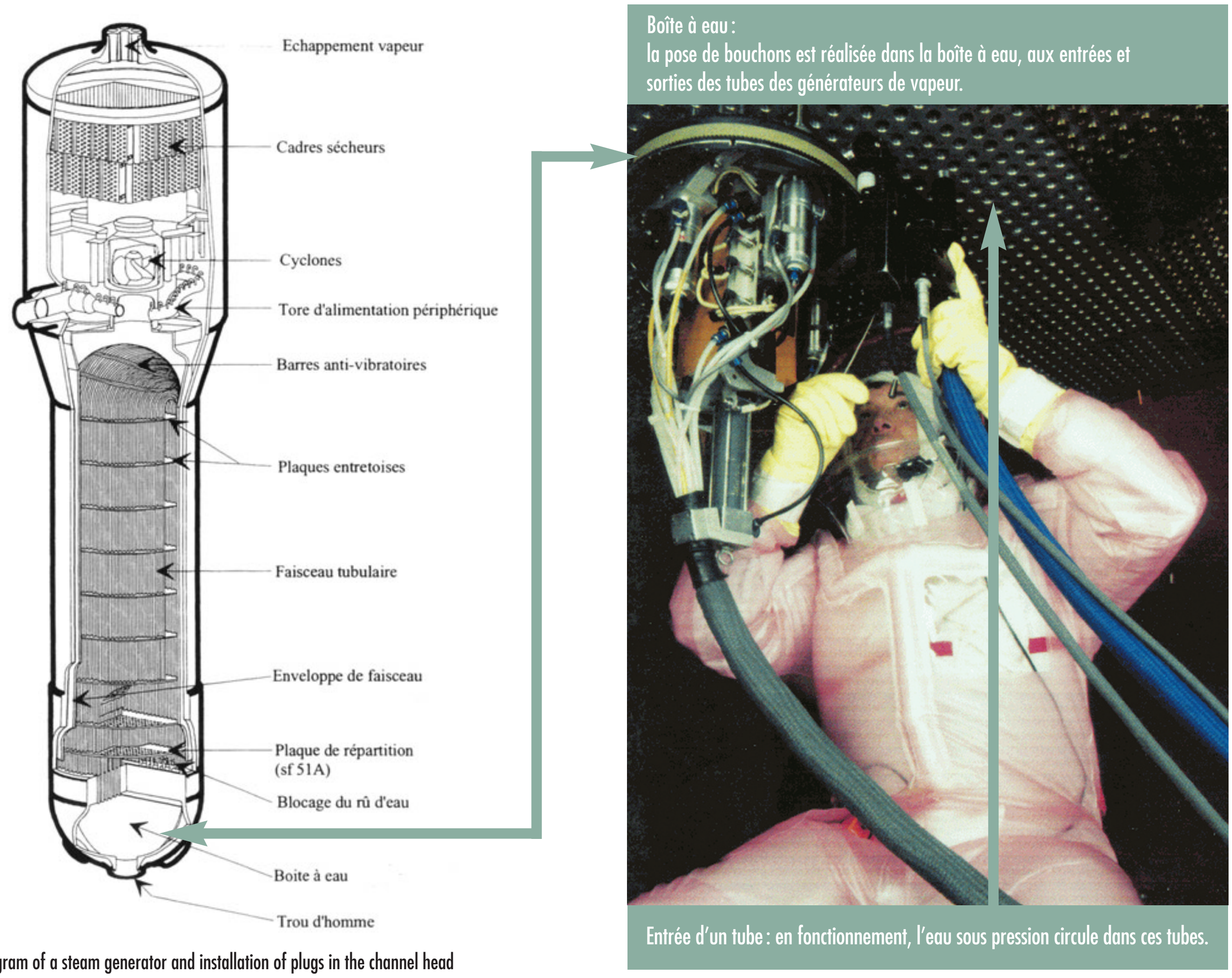
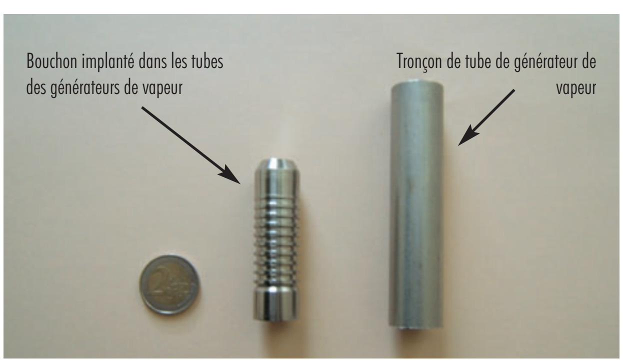
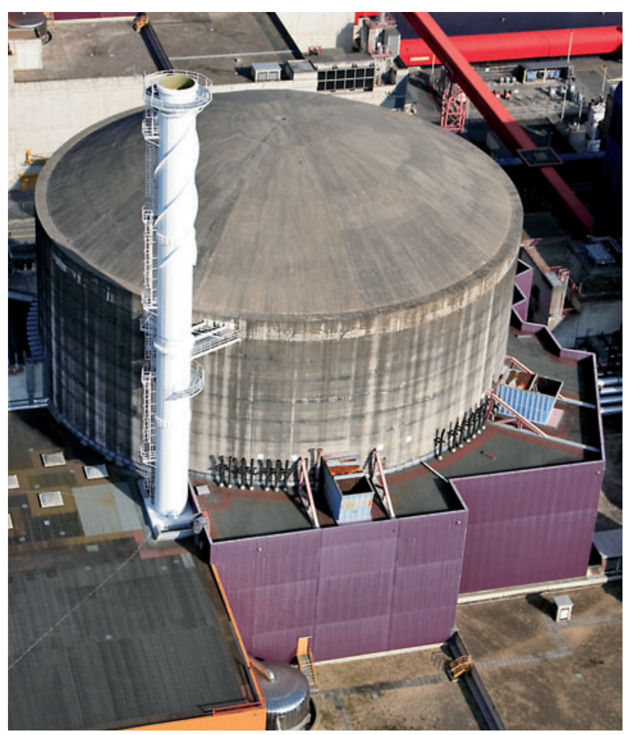


Diagram of a steam generator and installation of plugs in the channel head

the regulations. Their ageing was reviewed in 2005 as part of the 30-year periodic safety review, to assess their leaktightness and mechanical strength for a further 10 years. This review brought to light no particular problem liable to compromise the length of the service life. As part of this review process, EDF carried out studies to check the correct operation of the reactor building equipment access hatch 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.



Mechanical plug installed in steam generator tube bundle


Reactor containment in a reactor building at the Chooz NPP

The results of the ten-yearly outage tests on the 1,300 MWe and 1,450 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. This work is done at each ten-yearly outage. At the end of 2010, work had been carried out on 22 reactors out of 24. All the reactors concerned will have undergone the necessary maintenance work by 2012.

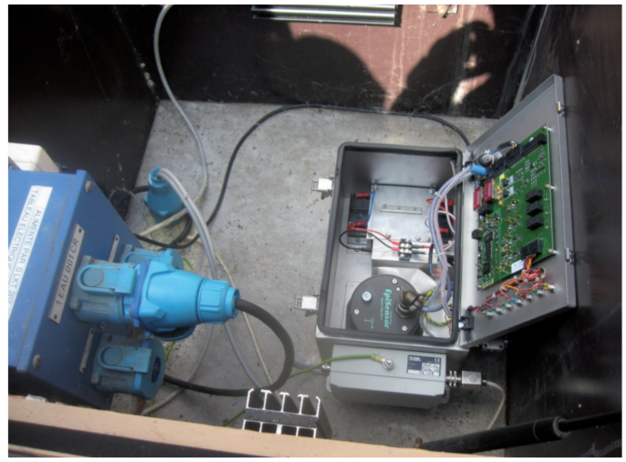
3 | 6 Application of pressure equipment rules and regulations

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

Such equipment (tanks, heat exchangers, pipes, etc.) is not specific to the nuclear industry. It is found in many sectors of activity such as the chemical and oil industries, in paper making and in the refrigeration industry. It is therefore subject to regulation set by the Ministry for Industry, which imposes the requirements with a view to guaranteeing its safe manufacture and operation.

The equipment in this category liable to allow radioactive releases in the event of failure is called nuclear pressure equipment and is regulated by the order of 12 December 2005. In addition to the requirements applicable to conventional pressure equipment and contained in existing texts covering reactor primary and secondary systems, the order imposes additional safety requirements on nuclear pressure equipment that will come into force on 22 January 2011. In readiness for this deadline, EDF has begun the drafting of the documents required under the order and their examination by ASN began in 2010. Specifically, the procedures for classification of this equipment was the subject of a presentation to the advisory committee on nuclear pressure equipment.

ASN is also tasked with monitoring application of the regulations on the operation of non-nuclear pressure equipment in NPPs. This consists, especially through on-site checks, in ensuring that EDF is implementing the measures required of it. ASN actions in 2010 included 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 equipment safety. Their competence, limited at present to non-nuclear pressure equipment, could be extended to nuclear pressure equipment once the requirements associated with it, especially those corresponding to its safety roles, are fully established. In 2010, ASN carried out six certification renewal audits for these inspection departments and an initial certification audit for the Flamanville NPP inspection department.



View of a seismic monitoring device (accelerometer) in an NPP

Events in 2010 concerning pressure equipment, other than the main primary and secondary systems dealt with in point 3 | 4, include damage linked to corrosion and erosion mechanisms detected on the moisture separator-reheaters (GSS). These units, which dry and super-heat the steam from the steam generators, are items of pressure equipment consisting of a confinement with a diameter of more than four metres, a length of twenty metres and operate at a pressure of 17 bar and a temperature of 300 °C. Given the amount of energy they contain, they can, in the event of failure, represent a risk for the safety of personnel.

Although a complete inspection and repair programme was carried out and is still ongoing for these items of equipment for 1,300 We reactors, subsequent to events in 2008, other deterioration appeared in 2010 on equivalent units for 900 MWe reactors. The licensee has undertaken a programme of inspection and is developing repair solutions for the damaged zones. The deterioration observed in 2010 in several zones of the secondary system also led ASN to be particularly vigilant regarding compliance with the procedures for pilot equipment monitoring developed by EDF.

3 | 7 Ensuring hazard protection

3 | 7 | 1 Prevention of seismic risks

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 reviewed regularly in order to take account of new knowledge and are applied on a case by case basis during the 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 of sustained attention by ASN.

Design rules

Basic safety rule (RFS) 2001-01 of 31 May 2001 defines the methodology for determining the seismic risk to surface BNIs (except for radioactive waste long-term repositories).

RFS V.2.g on seismic calculations for civil engineering structures was reviewed and published in 2006 in the form of guidelines (Guide n° 2/01 of 26 May 2006) on inclusion of seismic risk in the design of civil engineering structures for surface BNIs except for radioactive waste long term repositories). It is the result of several years of work by 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.

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 safety reviews associated with the third ten-yearly outages of the 900 MWe reactors, ASN asked EDF to examine the seismic design of the electrical buildings of CPY reactors and to 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 reinforcement changes for equipment and structures, with work beginning in 2009 during the ten-yearly outages of the Tricastin 1 and Fessenheim 1 reactors. 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 third ten-yearly outages of the 900 MWe reactors. With regard to the safety review associated with the second ten-yearly outages of the 1,300 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 of the next seismic reviews (review at forty years for 900 MWe reactors and at thirty years for the 1,300 MWe reactors), ASN has set up a working group bringing together EDF, IRSN and ASN. The aim of this working group is to determine the reference earthquakes to be considered for these forthcoming reviews. The discussions concerning the 1,300 MWe reactors ended in June 2009. EDF therefore sent ASN a technical report proposing updated seismic levels to be taken into account during the safety review associated with the third ten-yearly outages of the 1,300 MWe reactors. ASN sets the safety objectives applicable to nuclear installations and, accordingly, established its position on these proposals in 2010. ASN also takes 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 Drafting flood prevention rules

Following the flooding of the Le Blayais NPP in December 1999, EDF began to reassess the external flooding risk and the protection of its NPPs against this risk. This reassessment mainly concerns a revision of the maximum design flood level (CMS: maximum water level considered when designing the plant's protection structures). 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 were also reassessed. A file was produced for each NPP and works to improve the protection of the sites 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.

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 GPR and GPU 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. A problem was raised on this occasion: the safety of certain installations with regard to off-site flooding depends to a large extent on the behaviour of off-site structures not belonging to EDF, in particular with regard to the Cruas-Meysse and Tricastin nuclear power plants. Evaluating the robustness, the monitoring and maintenance of such structures entails taking action governed by a decision-making process that involves the concession-holders for the structures, the public authorities and EDF. Given this situation, ASN reminded EDF of its responsibilities as licensee and asked it to continue its exchanges with the concession-holders for the structures concerned and to keep it informed of progress.

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 asked IRSN for its opinion. At the same time, a working group of experts from IRSN, licensees' delegates and ASN undertook review of the RFS1.1 on integration of the flooding risk. 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. This draft guide from the working group was the subject of consultation in 2010. The GPR and GPU will meet in 2011. ASN should publish this new guide in 2012. 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 obtain a single guide (replacing the various IAEA guides on the subject);
– to take account of new phenomena;
– to take account of all NPPs.

Overall aerial view of the Blayais NPP on the Gironde estuary

2010 was also marked by triggering of the on-site flooding emergency plan (PUI) on two occasions at Le Blayais NPP in anticipation of the violent winds of 28 January. ASN's crisis centre was activated for this event. The PUI was lifted in both cases as the situation improved with regard both to the water level in the Gironde river and the wind speeds. The Blayais site was not flooded.

3|7|3 Preventing heatwave and drought risks

The heatwave in the summer of 2003 had significant consequences for the environment of NPPs: some water courses experienced reduced flows and significant rises in the temperature of waters some of which are used for cooling in NPPs. The heatwave also resulted in increased air temperatures, causing a temperature increase within the NPPs. During this period of heatwave and drought some physical limits that had hitherto been applied to NPP design or imposed by the GOR were reached. EDF accordingly proposed a set of "intense heatwave" references examining and reassessing the operation of installations under more severe conditions than those envisaged for design, applying higher hypothetical air and water temperatures. EDF proposed a version of these references for the 900 MWe reactors and a version for the 1,300 MWe reactors. The references for the 1,300 MWe reactors will be forwarded for the safety review associated with the reactors' third ten-yearly outages. ASN established its position on the 900 MWe and 1,450 MWe reactor references in 2009. At the same time, EDF introduced modifications improving the cooling capacity and reinforcing the withstand capacity of equipment sensitive to high temperatures.

Managing the risk of fire or explosion

At the same time, EDF introduced an in-house heatwave watch in order to anticipate any climate changes that could compromise the scenarios used in the "intense heatwave" references. As part of the safety review associated with the third ten-yearly outages of 1,300 MWe reactors, ASN will give its judgement on the adequacy of the organisation put in place by EDF to observe climate trends and to ensure the validity of the hypotheses used in the reference documents.

ASN is taking part in the national heatwave watch. With regard to this issue, ASN has instituted a decision-making process in case of heatwave.

3|7|4 Taking account of the fire risk

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 types and quantities of combustible materials in the NPPS – whether present permanently or temporarily – remain below the hypothetical levels used in designing sectoring;
– 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.

3 | 7 | 5 Checking that the explosion risk has been considered

Amongst the accidents that could occur in an NPP, explosion represents a major potential risk. Explosions 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. It then asked EDF to review the associated provisions for protection of the 900 MWe, 1,300 MWe and 1,450 MWe reactors.

ASN also looks at the preventive and monitoring measures implemented regarding the risk of explosion, thereby ensuring that:
– EDF includes this risk in its reference documents with regard to all gases (and not only hydrogen), for all of the buildings on its sites (and not only the reactor building) and for all operating and maintenance phases;
– dissemination of these references is effective for all sites as soon as possible.

ASN also ensures compliance with explosive atmosphere (ATEX) regulations and has thus requested that EDF introduce organisation that will allow identification of the areas at risk as well as classification by zone and the associated modifications. ASN inspectors verify the effectiveness and appropriateness of this organisation during their site inspections.

3 | 8 Oversight of application of labour legislation in NPPs

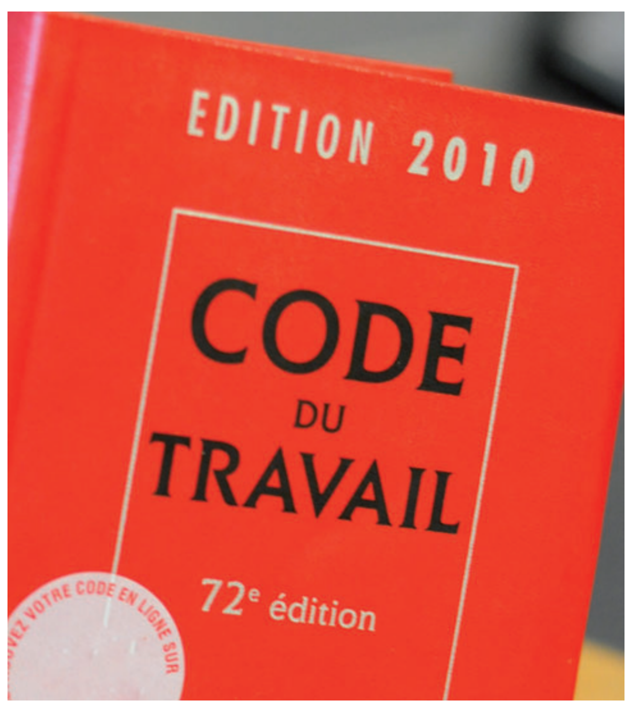
Pursuant to Article 57 of the TSN Act and the Labour Code (Article R 8111-11), ASN is responsible for monitoring safety and for occupational health and safety inspection duties in the NPPs. The health, safety, working conditions and quality of employment of the employees of EDF, its contractors and their subcontractors, along with the safety of the NPPs, are now regulated on a coordinated basis by ASN. These duties concern the construction, operation and decommissioning phases of NPPs.

The main duties of the ASN officers in charge of occupational health and safety inspections are:
– to ensure compliance with the labour regulations, by checking that they are effectively and correctly applied, by all means at its disposal, but also by helping EDF to assimilate and implement the requirements of these regulations;
– to investigate work accidents and ensure that the licensee is taking the necessary steps to guarantee worker safety;
– to take decisions concerning the organisation of work (working or rest time waivers) and professional relations;
– to identify and whenever possible monitor labour disputes as part of its conciliation duties;
– to inform and advise employees, their representatives and employers and to take part in occupational health and safety committee (CHSCT) meetings;
– to inform ASN of any shortcomings or abuses not covered by labour legislation and of the situation in the establishments inspected.

This means that some 20,000 EDF employees and as many employees of service providers, either permanent or on temporary work sites, are covered by ASN's occupational health and safety inspection duties in the 19 operating NPPs, working on the 9 reactors being decommissioned and on building of the Flamanville reactor.

As of 31 December 2010, in order to fulfil its duties, ASN had 13 inspectors and a health and a central safety manager tasked with leading and coordinating the health and safety inspectors' network. The coordination duties are strengthened, the methods harmonised and the documentary resources and the results of documentary watch distributed. Finally, the links with the other NPP regulating activities are being consolidated in order to contribute to achieving the integrated vision of regulation that is being sought by ASN.

Coordination with the Ministry of Labour's General Directorate for Labour was strengthened in 2009 and was the subject of an agreement signed at the start of 2011.



Verification of application of the occupational health and safety regulations was ASN's main activity relating to conventional safety inspection in 2010

4 RADIATION PROTECTION AND ENVIRONMENTAL PROTECTION

4|1 Oversight of occupational radiation protection

As part of ASN's duties to regulate BNI's, as set out in Article 4 of the TSN Act, NPPs are subject to verification of their compliance with regulations on the protection of workers who may be exposed to ionising radiation. In this context, ASN's duty of care extends to all workers in sites, the staff of EDF and of service providers throughout the service life of an installation.

4|1|1 Oversight of radiation protection in operating NPPs

Radiation protection in operating NPPs is subject to control by ASN in two main ways:

– by carrying out inspections:
- focusing specifically on radiation protection, scheduled once or twice per year and per site;
- during reactor outages;
- subsequent to incidents involving exposure to ionising radiation;
- in the head office departments responsible for radiation protection doctrine;

– by examination of the files relative to radiation protection of workers. This may be examination of:
- events notified as significant where radiation protection is concerned;
- maintenance or modification files with national scope, with support from IRSN.

In addition, ASN provides EDF with an annual presentation of ASN's evaluation of the status of radiation protection in the operating NPPs. This annual report allows comparison of the ASN's assessment with that of the licensee, in order to identify possible pathways to progress. Meetings are also convened periodically to consider the progress of technical or organisational projects to be studied or to be implemented in the NPPs.

4|1|2 Radiation protection requirements for NPPs in the construction phase

When examining the files relative to new reactors, and in particular to the EPR, ASN has asked EDF to draw lessons from the operating nuclear installations in France and from similar installations operating in other countries, with a view to reducing the collective dose as far as reasonably achievable. To this end, ASN, working with IRSN, has examined design and construction procedures intended to reduce the collective dose and the individual doses of the most exposed workers. ASN also carries out radiation protection inspections for workers on construction sites, especially during non-destructive testing using radioactive sources.

4|2 Controlling the environmental and health impacts of NPPs

4|2|1 Reviewing discharge requirements

The TSN Act, and in particular its Article 29, task ASN with establishing the requirements on abstraction of water intake for BNIs and on discharge of radioactive substances from those installations (see Chapter 4, point 3|3|1). Where NPPs are concerned, ASN's objective is a review of most of the existing discharge requirements in order to attain better harmonisation between the different sites. The new discharge requirements now take the form of two decisions:
- the first of these, subject to approval by the ministers responsible for nuclear safety, sets the discharge limits;
- the second establishes the requirements for procedures for discharge and for intake and consumption of water.

ASN applies the following principles when requests for discharge authorisation or modification are received:
- for radioactive discharges, ASN tends to lower the regulatory limits on the basis of operating feedback on actual discharges, while taking account of the contingencies of day-to-day reactor operation;
- for non-radioactive substances, ASN has decided to establish requirements on discharges of substances that were not formerly regulated, in order to control virtually all of the discharges and to adopt an approach that is more in line with heightened awareness of environmental issues.

ASN sets discharge limits as low as possible, in the light of current technical knowledge and the economic situation, ensuring at the same time that they do not have significant impacts on people or on the environment, while allowing the installation to operate normally. Lastly, it should be noted that technological progress has made it possible to alter limits and decision thresholds, guaranteeing better determination of actual discharges.

Aerial view of the Dampierre-en-Burly NPP with its four production units

River Loire water take-off and discharge structures of the Dampierre-en-Burly NPP

Radioactive release 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 2010 results concerning radioactive effluent discharges are presented in graphs 2 and 3. Graph 2, "Liquid radioactive discharges", presents the 2010 discharges of liquid tritium and liquid non-tritium (carbon 14, iodine 131, nickel 63 and other beta and gamma emitting radionuclides) per pair of reactors. Graph 3, "Gaseous radioactive discharges", presents the 2010 discharges of gases (carbon 14, tritium and noble gases) and halogens and aerosols (iodine and other beta and gamma emitting radionuclides) per pair of reactors. Evaluation of the radiological impact of these discharges is presented in Chapter 4.

4|2|2 Oversight of waste management

Management of the radioactive waste produced by the NPPs operated by EDF is covered by the general framework for management of waste from BNIs, presented in Chapter 16 of this report. ASN ensures coherence between the management of waste from NPPs and of that from other BNIs. For this type of waste, and for non-radioactive wastes, ASN has the licensee's study reference documents, as required by regulations, described in Chapter 3 point 3|5|1.

The reference documents cover the following themes:
– a review of the existing situation, recapitulating the different wastes generated and their quantities;
– waste management procedures;
– organisation of waste transport;
– waste zoning;
– the status of current disposal options.

Each site sends ASN the details of the waste it generates annually, indicating the chosen disposal routes, an analysis of trends in comparison with previous years, a report on any discrepancies observed and on the functioning and organisation of the site for waste management, as well as any unusual occurrences. The outlook is also addressed. EDF currently classifies its waste as process waste, maintenance waste and other waste, distinguishing between waste from controlled areas and others. Meetings are held regularly between the licensee and ASN to allow exchanges of information and views regarding waste and its management, especially via annual reports.

These elements and the regulations constitute the basis ASN uses to regulate management of waste by EDF. During inspections, inspectors review the organisation of sites in terms of waste management, various other points such as the handling of anomalies, and visit areas where waste is stored temporarily or treated.

4|2|3 Increasing protection against other risks and forms of pollution

NPPs are covered by general technical regulations on BNIs as outlined in Chapter 3. However, they are also faced with highly specific problems with potentially serious consequences, such as legionella bacteria or the discharge of cooling fluids, discussed in more detail below.

Controlling the bacteriological 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 effluents from biocidal treatment.

To strengthen prevention of the risk of legionella arising from cooling tower operation (point 1|1|7), in 2005 ASN, together with the General Directorate for Health (DGS), required that EDF comply with new maximum legionella concentration limits in the cooling systems and introduced installation surveillance requirements.

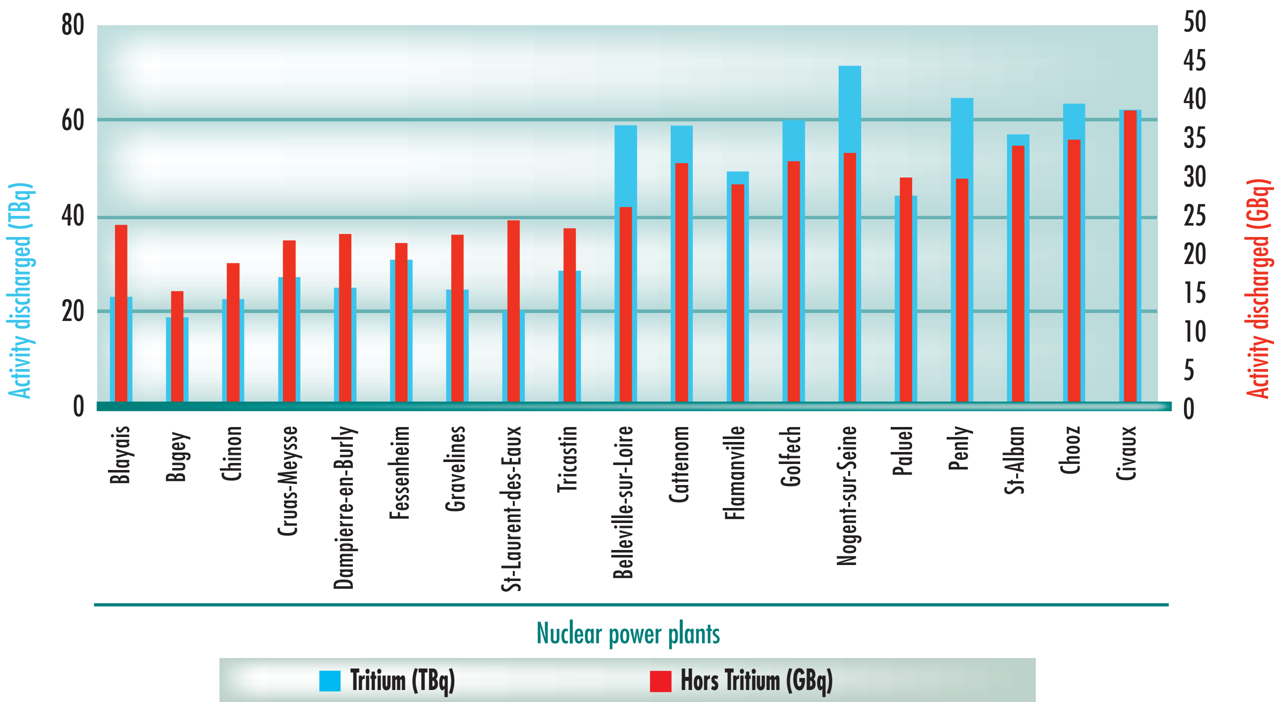
In 2008, ASN called upon the French Agency for Environmental and Occupational Safety (AFSSET) to better ascertain the health and environmental risks surrounding this issue. On the basis of an opinion given by AFSSET, ASN requested that EDF develop and implement preventive or

TO BE NOTED

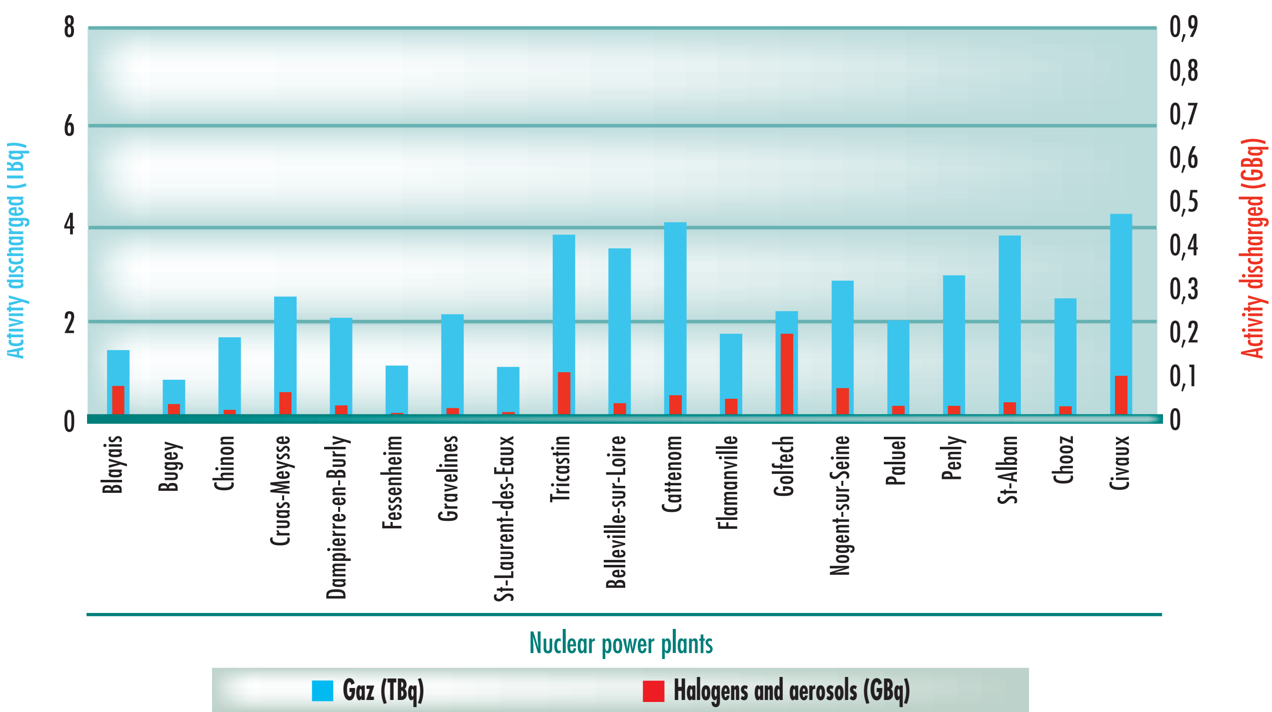
Legionella concentration levels in the large NPP cooling towers

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 systems other than the secondary system cooling systems (air-conditioning, etc.), application of the current requirements on installations classified for environmental purposes (ICPE) is requested.

Graph 2: liquid radioactive discharges



Graph 3: gaseous radioactive discharges



remedial means to reduce the risk arising from micro-organisms, whilst also seeking to minimise the discharges of chemicals resulting from treatments. Given the health implications of this issue – as some sites still have legionella "colonies" exceeding 10^5 CFU/l – ASN is monitoring progress of action plans closely while requiring EDF to investigate all alternative solutions to regular chemical treatments and all of the technical methods attenuating the impact of such treatments when they have to be used. By examining files and carrying out field inspections, ASN verifies the progress and the results of actions to combat legionella.

Reducing emissions of ozone depleting substances

In order to meet both industrial and service requirements, NPPs operate chillers. The technology used in these units involves a refrigerant fluid which is vaporised and condensed to allow heat transfer. Use of these refrigerants is regulated by a number of texts including European Regulation 1005/2009 which came into force on 1 January 2010. The regulation limits the production, placing on the market and use of substances that deplete the ozone layer. In addition, Decree 2007-737 of 7 May 2007 on certain refrigerant fluids introduces requirements on notification of state officials when a leak is detected or degassing is performed.

In 2009, ASN first requested that EDF produce an annual report and analysis of refrigerant losses. ASN also keeps a close watch on the progress of replacement of chiller units which must comply with a phase-out schedule set by European regulation[2].

5 CURRENT STATUS OF NUCLEAR SAFETY AND RADIATION PROTECTION

5 | 1 Oversight of the construction of the EPR in 2010

Detailed design review for Flamanville 3

The detailed design review is carried out by ASN with the technical support of IRSN on the basis of a documentary review. In 2010, ASN and IRSN continued their examination of the installation's control and instrumentation system and civil engineering, and initiated examination of the detailed design of some systems that are important for reactor safety, focusing on the innovative systems and those involved in reactor protection and safeguarding or in maintaining the three safety functions (see point 1).

In addition to the detailed design technical review carried out with the support of IRSN, ASN in 2010 conducted nine inspections in the engineering departments in charge of carrying them out and of monitoring manufacturing at the suppliers. ASN thus checked implementation of the requirements of the order of 10 August 1984 in the project management system, in particular the requirements concerning management and oversight of contractors, including by inspections carried out directly in manufacturers' facilities; identification and management of quality-related activities; management of anomalies; management of operating experience feedback; and the consideration given to human and organisational factors on the construction site. Implementation of these requirements was checked both in the engineering departments and on the FA3 construction site.

Oversight of construction activities on the FA3 NPP

With IRSN's support, ASN performed 24 inspections on the construction site in 2010. These in particular concerned the following technical topics:
– civil engineering, including installation of the steel liner on the reactor building inner containment wall;
– mechanical assembly activities;
– electrical system assembly activities;

Conventional safety inspection by ASN inspectors on the EPR site

2. Regulation n°2037/2000 (amended) established, as of 1 January 2010, the banning and placing on the market of HCFCs and of 1 January 2015 banning of the use of recycled HCFCs for maintenance and servicing of refrigerating and air-conditioning equipment. The latter date is included in European regulation 1005/2009 which recast Regulation 2037/2000.

TO BE NOTED IN 2010

Joint inspection of AREVA NP by ASN and Finnish regulator STUK

On 29–30 March ASN, with the Finnish regulator STUK, carried out a joint inspection of the manufacturer AREVA NP in a facility belonging to FIVES NORDON, one of AREVA NP's suppliers, located in Nancy (France). The follow-up letter to this inspection is published on ASN's website. The purpose of the inspection was to examine the actions taken after the discovery of unrecorded discrepancies in production of primary system pipes for the Olkiluoto EPR reactor (EPR OL3). The inspectors formulated requests to AREVA NP for remedial action regarding the quality of this supplier's risk analysis, the setting up of an internal inspection system, and formalising of quality habits and implementation of requirements relative to the quality system and to the manufacturing reference documents. Once AREVA NP had responded satisfactorily to these requests, manufacture of equipment for the Flamanville 3 EPR reactor was resumed in the supplier's facility, under condition of temporary heightened surveillance by AREVA NP and EDF. ASN also asked AREVA NP and EDF to draw all possible lessons from the shortcomings observed and to improve the efficiency of their systems for oversight of suppliers by introducing measures to detect early signs of a lowering of quality in production.

– non-destructive testing and radiation protection;
– organisation and management of safety on the construction site;
– the impact of the construction site on the safety of the Flamanville 1 and 2 reactors.
– the environmental impact of the construction site.

More specifically, in 2010, ASN paid particular attention to the following subjects:

– installation of a pre-stressing system for the reactor inner housing wall. On request from ASN, EDF provided justification demonstrating the absence of impact on reactor safety of the non-conformity in positioning of pre-stressing conduits that occurred in 2009. In June 2010, EDF notified ASN as to the presence in the poured concrete of a deformed pre-stressing conduit preventing passage of the pre-stressing cables as designed– repair was necessary;
– installation of a metal liner in the reactor building inner housing. ASN has been monitoring the building of this part of the structure closely since the end of 2008. At the start of 2009, ASN requested that EDF put in place an action plan to improve the quality of welding and, in the interim, to introduce 100% X-ray weld inspection. 2010 saw temporary deterioration of weld quality on two occasions, until EDF was able to bring in remedial and preventive measures. ASN carried out an inspection in July 2010 on this subject and asked EDF to improve the integration of lessons learned from the anomalies detected in 2009 for all of the welding activities on the site;
– method for dealing with construction joints to comply with the construction reference documents for civil engineering structures. Over the course of several inspections in 2009, ASN observed that construction joints were of inadequate quality and that the treatment methods used for these construction joints were not those given in the applicable construction reference documents. ASN asked EDF for justification of methods different from those in the reference documents. EDF then performed tests to justify the behaviour of the construction joints made using alternative methods. The results were presented to ASN and IRSN at the end of 2010. ASN will make known its position regarding these issues in 2011;
– event with significance for safety on the Flamanville 2 reactor relating to construction activities for Flamanville 3. In June 2010, a worker on the Flamanville 3 construction site carried out partial penetration of a concrete block containing one the 400 kV cables supplying the Flamanville 2 reactor: EDF's monitoring played its role in that the penetration was stopped before damage occurred to the cable. This event serves as a reminder of the importance of controlling risks on the reactors operating on the Flamanville 3 site. ASN carries out periodic inspections of the Flamanville 3 site and of the operating Flamanville NPP to check that the measures introduced by EDF concerning these risks comply with ASN's requirements.

Occupational health and safety inspection on the FA3 reactor construction site

Occupational health and safety inspections have been carried out by ASN since signing of the DAC. The action taken in 2010 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 requests from employees;
– response to requests concerning risk prevention plans on construction sites with a large number of contractors.

In 2010, ASN's occupational health and safety inspectors in particular verified that the contractors working on the site complied with the requirements of the Labour Code concerning the declaration of foreign workers, working hours, the risks involved in simultaneous work and the incorporation of operating experience feedback from the others reactors in operation into the design of this reactor.

Regulation of nuclear pressure equipment manufacture

In 2010, ASN and the accredited organisations continued examination of the files relative to the design and manufacture of primary and secondary equipment for the EPR, most of which is currently being manufactured (vessel, primary coolant pumps, control rod drive mechanism, pressuriser, steam generator as well as some of the piping and valves). ASN and the accredited organisations performed 776 inspections to monitor manufacture of this equipment, corresponding to 1,000 days of presence in the facilities of the manufacturer AREVA NP and those of its suppliers and

Management of an electric transformer fire at the Paluel NPP – April 2010

subcontractors. At the end of 2010, ASN and the approved organisations also oversaw the carrying out of the pressure testing marking completion of manufacture of the first items of nuclear pressure equipment or their components to be used for the Flamanville 3 EPR reactor (vessel body, valves, pipes).

5 | 2 ASN review of safety options for new ATMEA reactor

Several countries around the world are considering the construction of new NPPs. In this context, the ATMEA company, a joint venture formed between AREVA (France) and the Mitsubishi Heavy Industries (MHI, Japan), has called on ASN to review the safety options for a new pressurised water reactor known as ATMEA 1. According to ATMEA, this medium power reactor (1,100 MWe) is mainly intended for export. ASN has responded favourably to ATMEA's request and signed an agreement specifying this review. The purpose of the safety options review, carried out with IRSN's support, is to ascertain whether or not ATMEA 1's safety options comply with French regulations. Initiated in the summer of 2010, this examination is conducted under the same conditions as for a BNI that would be built in France. During the technical examination, ASN will call on the advisory committee for nuclear reactors (GPR). ASN will publish the conclusions of the examination at the end of 2011. The review will also allow ASN to assist the regulators in countries building reactors, if necessary.

*The **safety options file**, compiled by the operator, is used to present ASN with the main characteristics and general design choices made in terms of safety. The file, prepared in the reactor preliminary design phase, presents, notably:*

- *the safety objectives for the reactor;*
- *the safety approach applied in design;*
- *the overall description of the reactor and of the processes and systems used;*
- *the operating conditions envisaged as well as key parameters of the installation;*
- *accidents and attacks considered in design, and methods for dealing with these.*

5 | 3 Notable findings relating to fire and explosion risks

Transformer fires

Two transformer fires occurred in NPPs in 2010. The transformers are located outside of the nuclear area and serve to place the energy produced by the reactor on the electricity grid. In both cases the licensee activated the internal emergency plan (PUI) to mobilise all of the resources needed to manage the events.

The first fire broke out on 8 April 2010 on the line transformer of reactor 3 in the Paluel NPP. The second occurred on 25 July 2010 on one the terminals of the reactor 2 line transformer in the Tricastin plant.

These two events were the subject of inspections by ASN. In particular, the inspectors looked at how the event progressed, the actions taken to shut down the reactor and the progress of the firefighting response, provided jointly with the response team of the *Départmental*[3] fire and rescue service (SDIS).

Fire risk studies

As of 31 December 2009, ASN had received fire risk studies from 19 sites, in compliance with the timelines set in Article 11 of the government order of 31 January 2006 amending the order of 31 December 1999 establishing the general technical regulations intended to prevent and limit external nuisances and risks from the operation of BNIs. In 2010, ASN undertook examination of these studies, distinguishing between the parts specific to a particular site and those that are more generic and applicable to the installed base of NPPs. ASN has already asked EDF for further information on the requirements envisaged for some areas such as turbine halls and tunnels.

3. *Département*, in France an administrative region headed by a *préfet*.

Positioning reinforcing bars on the EPR site – October 2009

5 | 4 Notable findings relating to occupational health and safety inspections

Closer monitoring of occupational health and safety regulations

ASN's main occupational health and safety inspectorate activity in 2010 was monitoring of the implementation of the regulations concerning health and safety in the workplace. Workers in NPPs are not only exposed to risks relating to the "nuclear" aspects of their activity, but also to "conventional" risks such as those from electrical installations, pressure equipment, chemicals, explosion (in hydrogen systems), asphyxiation (from nitrogen), working at height or handling of heavy loads.

In 2010, occupational health and safety inspection activities covered the following areas:
- risk of falls on site: limitation of rope access work (mountaineering techniques);
- systematic investigations following serious industrial accidents. In several cases, health and safety inspectors observed failure to comply with regulations relating to work equipment and in terms of organisation of subcontracted activities (prevention plan); in addition, one fatal accident case was the subject of an inquiry concerning the victim's working hours; no notable discrepancy was found;
- compliance with the requirements of the Labour Code by the companies working on the construction sites, in particular with regard to simultaneous work by more than one contractor required for operation or maintenance of the NPPs;
- activities involving the use of carcinogenic, mutagenic or reprotoxic chemical products; EDF and its service providers were encouraged to take steps in line with the principles of prevention: eliminate the risk or limit exposure of workers to these substances, or find less hazardous alternatives;
- work close to the reactor while it is operating at full power, in terms of exposure to ionising radiation and heat, but also of the psycho-social risk factors.

The regular presence of inspectors on the hygiene, safety and working conditions committees (CHSCT), allows the inspectors to follow the activity of these bodies and to be informed regularly about relevant subjects, notably concerning occupational accidents and psycho-social risk factors.

Monitoring working hours travail

ASN's occupational health and safety inspectors carried out inspections of compliance with regulations on working hours as well as on daily and weekly rest periods specifically during reactor shutdown for maintenance. In 2010, they once again detected anomalies concerning the maximum daily and weekly working hours and rest periods. The infringements observed relate to periods of high activity (maintenance during reactor shut down).

Other areas

The occupational health and safety inspectors were called on to examine subjects raised by the workers' representative bodies, in particular:
- arbitration concerning implementation of the right to warning of serious and imminent hazard by the CHSCTs;
- the quality of services provided and, in particular, services provided by foreign companies, while monitoring correct application of collective agreements and the notion of service provider autonomy.

The inspectors also participated in joint work within the operational committee for the prevention of illegal labour (COLTI) led by the *Procureur de la République*[4], especially where the EPR site is concerned.

Penal procedures

ASN's occupational health and safety inspectorate issued five violation notifications to the relevant jurisdictions. Four of these related to violations that led to occupational accidents.

4. Public prosecutor.

On-site work conditions and risk of falling – October 2009

Surveillance of a spent fuel pool by ASN inspectors – November 2010

5 | 5 Notable findings relating to radiation protection of personnel

Zinc injection

ASN authorised EDF to inject zinc into the primary system of 16 reactors. This practice is in line with the overall approach to reduce the collective dose based on modification of the primary coolant chemistry. This operation was identified by EDF, notably in practice in other countries, as a means of reducing contamination of the primary system by the radioactive isotope of cobalt deposited in the system walls.

Two events with significance for radiation protection at the Chinon NPP

On 23 April 2010, during a check on cleanness at the bottom of the spent fuel pit, an operative's hand was irradiated while picking up and then handling an activated metal part (see box point 6 | 1 | 5).

On 4 August 2010, during a cleanness check on the steam generator water box, an object generating high levels of radiation was picked up by an operative then handled by three other operatives in succession before being removed from the zone.

These events were classified, respectively, at levels 1 and 2 on the INES.

ASN carried out a site inspection after each of these events: the inspectors observed that these incidences of accidental irradiation were, notably, due to inadequate analysis of the risks and to a lack of knowledge of how to act in the presence of undesirable objects detected during cleanness checks.

ASN inspectors equipped to check the Legionella risk

Examination of the EPR file

ASN is also continuing to examine the situation prior to commissioning of the EPR, in particular concerning activities where radiological issues are of great importance and the "two rooms" concept, which involves a new area in the reactor building enabling certain maintenance operations to be carried out while the reactor is operating. The general examination of the EPR is presented in point 2 | 4 of this chapter.

5 | 6 Notable findings relating to the environmental impacts of NPPs and discharges

Review of discharge requirements

In 2010, ASN completed its review of the effluent discharge and water intake files for the Saint-Laurent-des-Eaux and Flamanville NPPs.
– effluent discharges and water intake at Saint-Laurent-des-Eaux are now regulated by the ASN decisions of 18 May 2010, 2010-DC-0182 and 2010-DC-0183, published in the ASN Official Bulletin on its website;
– effluent discharges and water intake at the Flamanville site (two operating reactors and the EPR type reactor) are regulated by decisions 2010-DC-0188 and 2010-DC-0189 of 7 July 2010 published in the ASN Official Bulletin on its website.

Furthermore, in its White Paper on Tritium of July 2010 (*http://livre-blanc-tritium.asn.fr/*), ASN asked EDF to provide a critical study of the radiological impact of radioactive discharges at the Flamanville site, taking account of a weighting factor (wR) for tritium equal to two (see Chapter 4). Increase in the dosimetric impact linked to a weighting factor of two does not affect the magnitude of the annual effective doses due to discharges from the Flamanville site, which remains less than 2% of the regulation limit set at 1 mSv/yr for a member of the public by the public health code.

ASN reminded EDF of its request to include this critical study in the impact studies in the effluent discharge and water intake files submitted in July 2010.

Experience feedback from SOCATRI

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 drafted a verification programme at the end of 2008, which was implemented in 2009. The programme concluded with the drafting of a summary for the sites and of a national summary, currently undergoing examination by ASN.

From the site reports and inspections, ASN was able to observe that EDF's inspection work for these installations had been significant and that its central departments had been driving forces in terms of use and pooling of feedback. Examination of the summaries nonetheless highlighted the importance of the need for checks to be exhaustive, especially when systems are not easily accessible (underground pipes, etc.).

Replacement of a steam generator at the Blayais NPP in 2009

Actions to combat legionella

In 2010, EDF presented ASN with a report on actions undertaken to combat legionella since 2008. These indicated progress in terms of piloting of installations (control of legionella risk and of the impacts of biocidal treatments used) as well as improvements in the quality of the associated monitoring. However, ASN is also of the opinion that the efforts made by EDF to develop an alternative industrial scale solution to the current biocidal treatments should be pursued and that the situation on some sites not having biocidal treatments remains delicate from the health point of view, with legionella colonies sometimes exceeding 10^5 CFU/l. It is therefore pursuing its dialogue with EDF in order to further investigate the different possibilities for improvement.

5 | 7 Notable findings relating to oversight of pressure equipment

ASN is of the opinion that the safety case for prolonging vessel service life until fourth ten-yearly outages is acceptable

The safety case for keeping reactor vessels in service (see point 3 | 4 | 3) is covered by a special file that is regularly updated and examined by ASN. In provision for the establishment of a position on operation of each 900 MWe reactor until the fourth ten-yearly outage (VD4), EDF has submitted a justification file that is the subject of technical examination by ASN and IRSN. After consultation with the advisory committee for nuclear pressure equipment in June 2010, ASN established its position regarding the adequacy of this demonstration which completes the steps taken by EDF with regard to monitoring of ageing and in-service oversight of reactor vessels.

ASN and IRSN examined the safety case for keeping reactor vessels in service to ensure its compliance with regulations and to verify the validity of the calculations and of the assumptions made. The purpose of analysis was to ensure that the results provided at each calculation step were conservative, and that the safety margins required by regulations were respected.

EDF's calculations indicated compliance with regulatory criteria during the decade following the third ten-yearly outages (VD3). ASN also noted that EDF is able, if necessary, to rapidly provide technical solutions, such as heating of the safety injection, that guarantee that faults are not harmful if new elements arise that could compromise the content of the current file. ASN considers that all of the 900 MWe reactor vessels are fit for service during the decade after the third ten-yearly reactor outages. ASN will verify that the inspections performed during the ten-yearly outages are such that they ensure that no new faults will appear and that faults already detected will not worsen.

ASN did, however, formulate some requests intended to further improve the methods employed, to continue studies to confirm current data and to correct certain elements for which EDF had not given sufficient guarantees as to their conservative nature.

Shutdown of Bugey 3 reactor awaiting replacement of its steam generators

During a shutdown for maintenance of reactor 3 at Bugey, in April 2009, EDF's inspections revealed a new type of damage of the steam generator. Following this discovery, EDF introduced a programme of checks and expert examination of which the results are the subject of a major examination by ASN and IRSN.

In order to characterise the condition of the Bugey 3 steam generators, EDF has set up a programme of checks of all of the steam generator tubes appropriate to the type and number of incidences of damage detected. The checks were carried out with means specially developed for the purpose and processes used in other countries that had not yet been used in French NPPs. They continued until September 2009.

Inspection of the tubes was competed by extraction of several of them for expert laboratory examination, to determine the precise nature of the faults encountered and to guarantee the ability of the checking procedures to detect them.

The damage revealed by expert examination indicated corrosion phenomena, locally deep and associated with cracking. This damage was located on the tubes at the circular section support plates and only concerned Inconel 600 MA alloy tubes.

Before establishing a position on the risk of steam generator tube rupture and the absence of risk of a significant leak between the primary and secondary systems during the Bugey 3 reactor's next operating cycle, ASN, with IRSN, has examined the results of the checks and studies performed by EDF and obtained the opinion of the advisory committee for nuclear pressure equipment, which met on 19 April 2010.

On the basis of these elements, ASN considered that the means for checking and for expert examination introduced by EDF were appropriate for the characterisation of this type of damage. However, ASN was also of the opinion that the measures proposed by EDF initially, prior to possible restarting of the reactor before replacement of the steam generators, were inadequate and should be completed, notably with regard to conducting of a complete pressure test on steam generator 1. The hydraulic pressure test at a pressure of 207 bar, greater than the maximum pressure occurring in an accident situation, was considered to be the only means that could guarantee leaktightness of tubes.

Taking account of the constraints relating to the carrying out of such an operation, EDF chose to bring forward replacement of the steam generators, initially scheduled for September 2010, to July 2010. ASN acknowledged this decision which is beneficial to reactor safety, but pointed out that it could have been foreseen given the extent of corrosion of the tubes on steam generator 1 at Bugey 3.

Amongst the other reactors that may be affected by this type of damage, Fessenheim 2 has also shown signs of atypical damage and been the subject of additional checks and expert examination intended to provide understanding of the phenomenon and for characterisation of the condition of the steam generator tube bundles. The other sites concerned, Le Blayais 2, 3, 4, Gravelines 3 and Chinon B2, were found to be less affected by corrosion.

ASN asked EDF to carry out preventive plugging on Fessenheim 2, in order to offer sufficient guarantees concerning the serviceability of the steam generators of this reactor for the forthcoming cycles. The inspection and maintenance programmes for the other reactors have been amended accordingly.

The steam generators concerned by these phenomena will be replaced between 2011 and 2014, in accordance with EDF's schedule.

The steam generator replacement programme

2010 was marked by the replacement of the steam generators on the Bugey 2 and 3 reactors, in accordance with EDF's decision to replace the steam generators with 600 MA alloy tube bundles. The design of the building of the CP0 plant series (Fessenheim and Bugey) requires introduction of the steam generator into the reactor building in two parts and final joining of the two parts on site.

EDF also plans to replace the steam generators equipped with 600 TT alloy tube bundles that have been proven to be sensitive to corrosion damage, but to a lesser extent than those in 600 MA alloy. The 1,300 MWe reactors are also concerned by these operations, with the first replacement scheduled at Paluel for 2015, because of a high level of cracking in the dudgeonning transition zone. This will be followed by replacement on the Flamanville reactors in 2017 and 2018, the others being programmed between the third and fourth ten-yearly outages.

6 ASSESSMENT

Operating reactors

6 | 1 Evaluating the head offices and overall performance of NPPs

The following general assessment provides a thematic summary of ASN's evaluation of the head office departments and of the performance of EDF NPPs in terms of nuclear safety, radiation protection and the environment.

Evaluation is based on the results of checks carried out by ASN in 2010, 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 2010, ASN conducted 491 inspections in the nuclear power plants in service and in EDF head offices.

The general assessment represents ASN's view of the year 2010 and acts as a guideline for ASN regulation and inspection actions for 2011.

6 | 1 | 1 Evaluating nuclear safety

Reactor operations

The documents required for operation are, on the whole, well managed, cover the different operating phases and provide an accurate picture of the actual status of the installations. Anomalies in application of the rules for periodic testing are less numerous than in previous years.

Management of training and operating personnel authorisations is satisfactory.

Improved operational stringency remains a key priority for the NPPs and head office departments. ASN considers that the efforts made on this subject in recent years must be continued.

Efforts were made in 2010 to identify, manage and absorb a backlog of particular equipment and devices and temporary modifications that have remained in place on reactors for several years. These efforts should be continued.

Conversely, preparation for servicing work remains a weak point once again this year. Although ASN notes the beneficial effects of implementation of practices to improve reliability, these remain under-exploited and the managers of operating staff do not have the time needed to correctly fulfil their duties, especially during reactor outage. Similarly, oversight of the control room needs to be improved, to be able to detect any malfunctioning as early as possible.

The interfaces between operating and maintenance or testing personnel are often the source of anomalies, resulting from communication or misunderstanding. Actions to improve this situation must be identified and implemented.

In spite of the limited progress noted by ASN in the management of equipment lock out, numerous anomalies were once again recorded in this area in 2010, as well as in the area of circuit alignment. There is a lack of rigour and oversight where these operations are concerned.

Lastly, the stringent application of operating reference documents and temporary operating instructions still needs to be improved.

Emergency situations

ASN considers that EDF's management of emergency situations is highly satisfactory. Relations between ASN and EDF at national level have been strengthened in recent years, notably via meetings on the reference documents for EDF's internal emergency plans (PUI). However, ASN needs to be better informed about documents introduced to the sites by EDF's head office departments, such as the reference for emergency telecommunications (RMTC).

In 2010, EDF forwarded the new PUI reference documents to the different sites for comment. The comments were incorporated by EDF at the national level. ASN also forwarded its comments to EDF's head office departments; these are being incorporated by EDF.

ASN still considers that the emergency response organisation in case of ammonia release, introduced for sites with a monochloramine treatment facility, is not satisfactory, and it is still not operational on most of the sites concerned. This risk should be included in the "Toxic" PUI planned in the new reference documents.

Based on its inspections in 2010, ASN noted progress in the area of firefighting although there is still room for improvement, especially where performance of duties and the actions of response teams are concerned.

The different sites have made efforts to implement an organisation that complies with the requirements of the order of 31 December 1999 relative to the organisation of firefighting.

Further efforts are required in the area of sectorisation management and of prevention, especially regarding fire permits and fire loads.

Maintenance activities

In the area of maintenance, ASN observes that, in the past, EDF has failed to anticipate certain problems sufficiently far in advance and has not taken sufficient account of international feedback, with the result that it is now having to carry out delicate, large-scale corrective maintenance, notably on the steam generators, in order to guarantee safety. This lack of foresight in maintenance and equipment replacement programmes, with particular reference to the steam generators, has also resulted in recent years in very extensive inspection and expert examination programmes. However, ASN notes that EDF is now taking onboard the lessons of these observations by, for example, already planning a programme for replacement of these items of equipment for the 1,300 MWe reactors. Regarding the implementation of the maintenance policy on sites, ASN feels that EDF must be careful to ensure that adequate human and material resources are available.

Where implementation of maintenance methods on the sites is concerned, ASN considers that there is room for improvement in EDF's situation and that some recurring shortcomings remain:
– the maintenance references documents are in a state of continual flux in a variety of forms. The resulting complexity is a factor that aggravates the persistent delays in integration observed on all NPPs and tends to lead to disparate requirements;
– the quality of risk analysis in the preparation of maintenance operations remains unsatisfactory. It needs to be significantly improved on virtually all sites. Management of spare parts should also be improved;
– lastly, the quality of maintenance operations also requires greater consideration of human factors in the preparation stages of these operations.

Managing of contracting

Most maintenance activities on NPPs are entrusted to contractors selected on the basis of a qualification and evaluation system implemented by EDF. ASN is of the opinion that EDF has not made progress in its monitoring of these contractors since 2009. In particular, ASN sees no improvement in monitoring of the activities carried out by contractors in the field and considers that this needs to be rapidly improved and strengthened. ASN observes that monitoring of cascade subcontracting is either non-existent or too light. EDF must therefore check the adequacy of the quantity and quality of the resources allocated to monitoring of the activities subcontracted, given their implications for safety, radiation protection and protection of the environment. Furthermore, as in previous years, ASN has noted that the material resources provided for contractors are often inadequate or inappropriate, leading in some cases to degraded working conditions in terms of safety and radiation protection. ASN believes that it is necessary to ask EDF to reassess its industrial maintenance policy and its use of contractors to implement it.

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.

However, ASN believes that EDF should address the problem of obsolescence with regard to some items of equipment. In addition, EDF must reinforce its management of qualification of equipment for accident conditions, whether during preventive maintenance operations or when replacing equipment.

Pressure equipment

ASN considers that EDF has made progress in the management of pressure equipment. All of the NPP inspection departments are now recognised. ASN notes that the situation is satisfactory or is progressing on an increasing number of sites. ASN also notes that the recognised inspection departments (SIR) have acquired a certain degree of maturity and believes that EDF should continue its efforts to create such departments to allow them to carry out their duties on the basis of exhaustive inspection plans.

The first barrier

In ASN's view, in 2010, the situation regarding the first barrier was satisfactory on the whole but there are a few points where there is room for improvement, notably in the area of prevention of deterioration during operation. The long-term actions undertaken by EDF do not yet permit a return to an optimum status for the first barrier and, in 2010, ASN once again observed leaks in fuel assemblies, damaged support grids and the presence of numerous foreign bodies in the primary system.

Where grid damage and blocking of fuel assemblies during handling are concerned, ASN noted the general deployment of "improved grids", for which feedback in 2009 and 2010 was favourable, on the 1,300 MWe and 1,450 MWe reactors.

ASN also took a positive view of actions to prevent fuel grid blocking incidents such as those that occurred in 2008 and 2009 at Tricastin and Gravelines. The measures adopted improved the reliability of handling of the vessel upper internals and provided better detection of foreign bodies in the systems and fuel assemblies.

In 2010, loss of leaktightness on RFA fuel assemblies in some 900 MWe reactors was associated with fretting of these 900 MWe RFA fuel assemblies which are of an old design without spacer grid. Modification of the design of these assemblies means that this source of loss of leaktightness can be expected to disappear progressively within an acceptable period. Conversely, ASN considers that EDF should pursue the actions undertaken in relation to leaktightness of M5 fuel assemblies.

ASN also believes that EDF should make progress regarding preventing and dealing with foreign bodies in systems. The actions undertaken by EDF since 2008 are judged satisfactory, but they still appear to be only partially implemented and there should be more uptake of these actions by the different sites.

Finally, EDF should also make progress with the application of maintenance programmes for fuel handing equipment as this can, in the event of its malfunctioning, be the cause of damage to the fuel assemblies placed in the reactor core.

The second barrier

ASN considers that there is still room for improvement to EDF's situation regarding maintaining integrity of the second barrier. The particular case of the Bugey 3 steam generators – where the more in-depth inspections and associated expert examination led finally, before the equipment resumed operation, to early replacement of the steam generators – is an illustration of the possibility for improvement. However, ASN notes that the situation is improving with the implementation this year of EDF's strategy to maintain cleanness of the steam generator secondary system (chemical cleaning, conditioning at high pH, monitoring of chemical parameters and carrying out of preventive cleaning operations).

Chemical cleaning of steam generators was carried out in 2010 on the Cattenom 4 and Belleville 2 reactors. In the latter case the presence of hardened sludge on the tube plate and at the tube ends (formation of gangue) was detected. An additional high temperature de-oxidation phase was applied for the first time to remove the hardened sludge.

Preventive steam generator cleaning was used for the first time on Gravelines 5. To date, it is difficult to reach a conclusion as to the effectiveness of the process where fouling is concerned due to unforeseen circumstances that occurred during this operation.

Two satisfactory steam generator replacement operations were carried out in 2010, on the Bugey 2 and Bugey 3 reactors.

EDF continued to address the anomalies encountered during installation of mechanical plugs on steam generator tubes. The main cause of these anomalies is a lack of lubrication. EDF has accordingly undertaken the amendment of the plug manufacturing requirements.

The third barrier

Although it was felt in 2010 that the third barrier and its components could still be improved, ASN noted a reduction in the number of containment related events in relation to 2009. The trend observed in 2010 will, nonetheless, have to be confirmed in 2011.

The results of ten-year testing of the 1,300 and 1,450 MWe reactor containments conducted in 2010 complied with the criteria established in the operating rules. However, EDF will present ASN with technical solutions that will guarantee the leak-tightness of the containments over time, in spite of their ageing. Analysis of these proposals, which will begin in 2011, will be presented to the advisory committee for nuclear reactors in 2012.

6|1|2 Evaluating radiation protection

EIn 2010, ASN carried out 24 specific inspections in the area of radiation protection on sites and two inspections in EDF's head office departments. The inspections allowed ASN to observe that EDF had reacted to the observations of 2009 by revitalising the "as low as reasonably achievable" (ALARA) approach. While the collective dose in the NPPs had been on the rise for two years, EDF attained its collective dose objective for 2010 (see graphs 4, 5 and 6).

In view of these results, ASN considers it essential for EDF to sustain its renewed efforts regarding the ALARA approach during future reactor outages, and to ensure the long-term viability of improvements in the area of collective and individual doses.

ASN also observed that the action plan implemented by EDF to improve radiation protection for workers during industrial radiographic exposure continued to produce positive results.

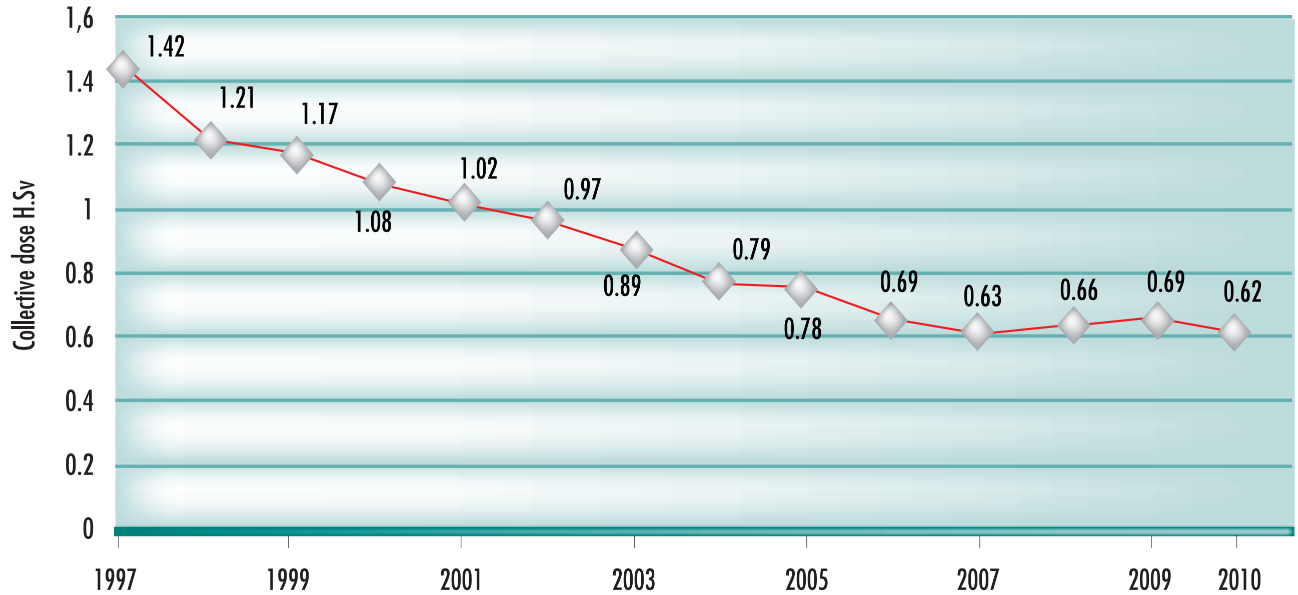
However, ASN observed wide variations across the installed base of NPPs where radiation protection is concerned and considers that EDF must be vigilant with regard to improvement on all sites. In addition, the different observations by the ASN inspectors, especially those made during inspections following the events in April and August 2010 on the Chinon site, serve as a reminder that the quality and integration of risk analyses and of dose optimisation studies are fundamental elements of the preventive approach and that EDF must still improve its performance with regard to these aspects.

ASN also considers that EDF should make improvements regarding the time required to integrate changes in regulations into its radiation protection framework.

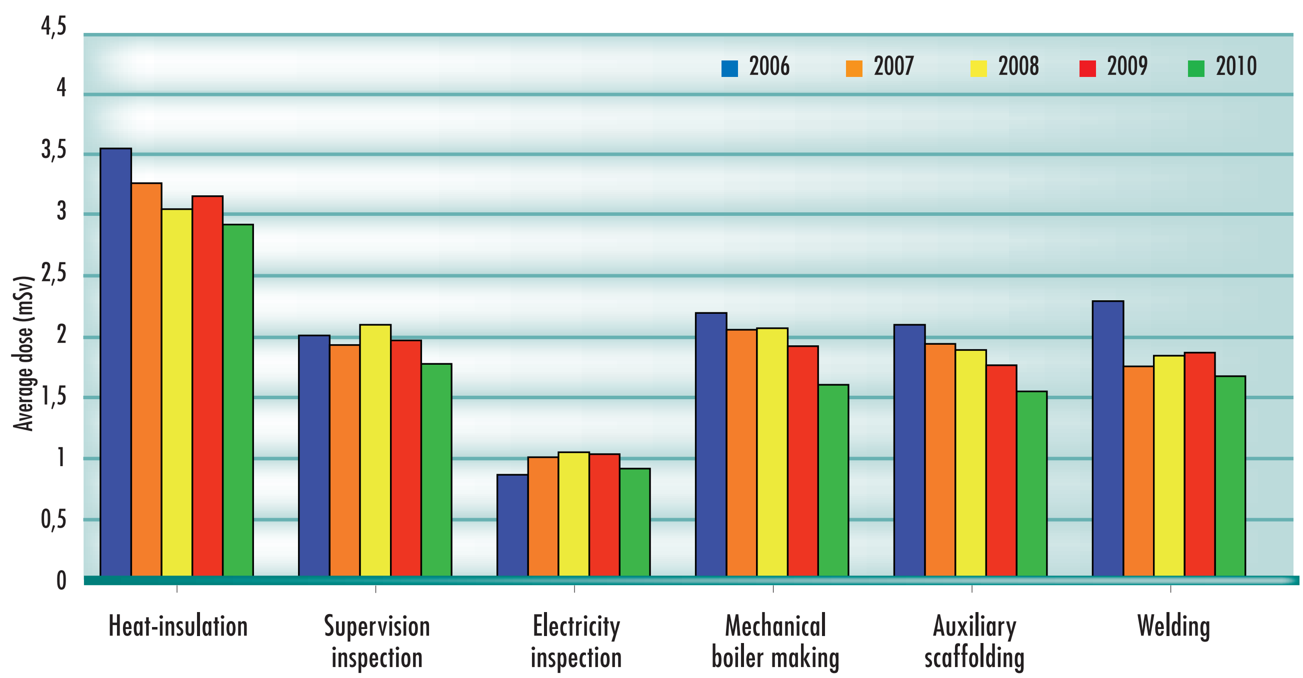
Lastly, ASN believes that EDF should look again at the quality and breakdown of the radiation protection duties of people involved in the preparation of sites and in carrying out work on them, especially in the light of the conclusions of the studies of

Graph 4: breakdown of the population per dose range for the year 2010 (EDF data)

Graph 5: mean collective dose per reactor



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



human and organisational factors (HOF). These considerations should feed into the policy for improvement and into EDF's objectives for controlling contamination at source, sharing feedback, monitoring application of site radiation protection rules and, more generally, for radiation protection culture.

6|1|3 Evaluating environmental protection measures

At the end of 2009, ASN warned EDF that it had observed a worsening of the situation regarding environmental protection. In 2010, ASN considered that EDF had taken a more dynamic approach to the issue but that this had not yet allowed the different sites to return to a satisfactory situation.

Therefore, although the environmental situation is satisfactory for most sites, ASN still observe numerous anomalies in the different NPPs. In fact, anomalies in compliance of installations, in implementation of corrective actions and in monitoring of contractors' activities were all highlighted in 2010. Furthermore, ASN inspectors observed several discrepancies in the application of the government order on discharges and the amended order of 31 December 1999, as well as anomalies in the management of conventional waste.

Some of these anomalies are the subject of modification of discharge requirement files that are being examined.

In addition, ASN yet again pinpoints flaws in the management of chillers, leading to releases of refrigerants to the atmosphere.

Lastly, ASN regrets that, in certain declarations of equipment modifications made under Article 26 of order 2007-1557, EDF did not adequately encompass all of the elements protected by the TSN Act.

In conclusion, ASN considers that EDF must consolidate and pursue its efforts to attain satisfactory environmental performance. Its efforts should result in a coherent industrial policy encompassing all of the elements protected by the TSN Act.

6|1|4 Analysing staff and organisational measures

Organisation of sites and staff

ASN is of the opinion that EDF's organisation for dealing with matters of nuclear safety and radiation protection is satisfactory, but that anomalies in application by the different sites persist, in particular regarding maintenance but also regarding operating departments.

In the area of nuclear safety, the plans for a rigorous approach to operation create a dynamic that is favourable to achieving the objectives that the sites with the lowest safety performance set for themselves. Conversely, other objectives, and notably those relating to reactor operation (monitoring in control room, excursions from the operating range, alignment and lock out anomalies) are more difficult to attain.

In the area of environment, ASN considers the objectives set by some sites to be far-reaching.

The roles and responsibilities within the departments are generally defined in organisation circulars but are not always actually applied in carrying out of activities. Anomalies observed, some of which lead to significant events, reveal a lack of clear perception of duties and difficulties in the distribution of roles between departments, notably between the operating department and the others. Lack of time means that management personnel cannot be as involved as they need to be, even though EDF has made considerable efforts at the national level.

Welding operation on a work site

Manning levels are generally speaking appropriate but ASN nonetheless observed shortcomings in this area during reactor outages. Conversely, the situation regarding oversight of contractors' activities is not satisfactory. The lack of human resources leads to inadequate oversight in the field, difficulties in overseeing un-scheduled operations or oversight being entrusted to "support" personnel, to contractors or to staff members who do not have the necessary authorisation.

Incorporating HOF in operating activities

ASN is still observing shortcomings in the organisation and resources employed on the different sites to incorporate human factors: obsolete organisation circulars, human factor consultants without prescribed duties, absence of local network of correspondents in the specific discipline departments, etc. ASN observed that human factor correspondents had no basic training. Lastly, the simultaneous presence on a site of a local human factors network with other local networks such as human resources performance, weak signal approach or change management can lead to confusion and requires strengthened leadership either on the sites or at national level.

ASN notes the considerable efforts made by EDF to develop implementation of practices to improve reliability of operations within the framework of the national "human resources performance" project. Training sessions are provided in simulator and on training sites under the training or retraining programmes, and some sessions on the training sites are open to contractors. However, ASN still observes shortcomings in the use of these good practices. ASN considers that the effort made by EDF should be pursued.

In general, managers are reinforcing their presence in the field. However, field visits are sometimes organised more with a view to monitoring the condition of installations under the "obtaining an exemplary condition for installations" (OEEI) project than with the intention of observing work situations under the "human resources performance" project. ASN has noted with interest that some sites associate or are planning to associate contractors with the field visits organised during reactor outages.

ASN also noted that on one site the weak signals detection approach is open to all staff. Overall, however, contractors are still only slightly involved in the issuing and characterisation of observations from the field. Furthermore, organisation of the weak signal approach relies heavily on department heads, who do not always have the time needed to develop it. Lastly, ASN notes that the observations made by managers in the field are sometimes insufficiently critical: licensees should make efforts to maintain more balanced proportions of positive and negative observations.

Ergonomics – resources and working conditions

ASN notes that ergonomic studies were conducted on sites in 2010 with the intention of either proposing solutions for improvement subsequent to events or to contribute to design and installation of new equipment or new premises such as, for example, the fitting out of the unit outage steering committee (COPAT) room.

In 2010, ASN was still finding numerous shortcomings relating to ergonomic problems concerning operating documents, equipment, work spaces and man-machine interfaces: equipment unsuited to tasks to be performed; restricted work spaces; inappropriate, incomplete or inaccessible documents; unsatisfactory identification; or indications that are difficult to read, sometimes leading to significant events.

For instance, an alignment error led to notification of a significant event when indication of the direction of rotation of a valve operating in the opposite direction to other valves was painted over. In addition, although the OEEI project contributes to an overall improvement in labelling and identification of equipment, ASN noted in 2010 that some work undertaken for the project had led to removal of labelling and indications and that these had not been replaced.

ASN emphasises the fact that ergonomic problems adversely affect operatives' activities since the conditions under which they work and the calm atmosphere they should enjoy are jeopardised by the constraints of organisation of work, changes in planning and problems of coordination between sites that cause delays or postponement of activities.

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

Overall, human factor consultants are integrated into the feedback analysis process, but the situation varies from site to site. They sometimes support the various disciplines, usually at their request, to help them analyse an event from the human factors standpoint. It would be desirable for the human factors consultants to be consulted more systematically by site management. When they exist, human factor correspondent networks in specific discipline departments are involved in event analysis, but in some cases their professionalisation warrants closer monitoring.

Skills and authorisations

The organisation of skills and authorisation management in place on the sites appears to be satisfactory and the management processes well documented and coherent. Shortcomings are observed by ASN during inspections: annual interviews not taking place; managers who do not systematically carry out the observation in the work situation that is necessary for evaluation of skills and renewal of authorisations; an IT application allowing tracking of "unusual actions" that is not up to date and is little used.

Provisional jobs and skills management (GPEC), which makes it possible to forecast and plan for future skills requirements, is satisfactory on the whole. However, ASN observed a case of failure to foresee a large proportion of operation planners taking retirement from the maintenance department of one of the sites.

Training programmes are, generally, implemented satisfactorily and the establishment of "academies" for the different professional disciplines is highlighted as a strong point for the training of newcomers to the sites. However, anomalies are still frequently observed during inspections or following significant events, especially in the areas of radiation protection and environmental protection: contractors with no or little awareness of environmental issues; shortcomings in training of people responsible for overseeing contractors, arising from a skills deficit. In 2010, ASN found a shortage of simulator instructors on some sites. ASN estimated the proportion of instructors having significant experience of NPP operation to be less than 50%.

It is also important that "buddy system" pairing actions be fully recorded in documents such as paring logs, that the tutors be recognised and that this activity be allowed for in individuals' work programmes.

In general, ASN observed that staff professionalisation logs were well kept and found few errors in staff authorisations. However, ASN did find some anomalies during inspections (operations requiring authorisation carried out by a staff member not yet authorised, an authorisation renewed without obligatory training having been validated, etc.).

Incorporating HOF when modifying reactors in operation

Where modifications of existing installations are concerned, ASN, with IRSN's endorsement, highlights the efforts made by EDF to develop an approach that integrates human factors into the technical and documentary modifications in NPPs and to disseminate this approach to the relevant engineering centres and to the different sites. In the engineering centres, improvements need to be made to the practices used for file analysis and the specialist HOF skills must be strengthened. Furthermore, ASN observed during inspections that the HOF consultants on the sites are very little associated with the implementation of this approach. More generally, the involvement of the sites in the engineering processes should be enhanced.

6|1|5 Analysing operating experience feedback

Significant events in 2010

Under the rules on notification of significant events in the areas of safety, radiation protection and the environment, in 2010 EDF reported 622 significant safety event (ESS), 90 significant radiation protection events (ESR) and 100 significant environmental events (ESE) (involving neither nuclear safety nor radiation protection). 717 events were rated on the INES.

Graph 7 shows the trends in the number of significant events reported by EDF and rated on the INES scale since 2005.

Graph 8 shows the trends since 2005 in the number of significant events per area concerned by the notification (ESS, ESR and ESE).

The number of ESS declared reduced by around 11% in relation to 2009: reduction is due, mainly, to the studies conducted as part of the examination of compliance associated with the third 900 MWe ten-yearly outages, which revealed several generic compliance anomalies in 2009 that have now been dealt with. Progressive introduction by EDF of a plan to harmonise its operating practices made a visible contribution to reduction. The number of ESS in 2010 returned to its 2008 level.

The number of ESR has been reducing since 2007. This is mainly due to continuous improvement in the resources used for protection against ionising radiation. However, this year also saw an ESR rated at 2 on the INES. As the body responsible for radiation protection in the NPPs, EDF must oversee the protection and the maintaining of a safety culture amongst its staff as well as amongst contractors' staff.

The number of ESE was stable in relation to the preceding year but remains high in relation to other years. Protection of the environment must remain a central concern for EDF.

Graph 9 shows the average number of significant events in 2010, rated at levels 0 and 1 on the INES, and per standardised plant series. The slightly higher average for the N4 series is mainly due to the fact that reactor outages were more numerous for this series in 2010. The increased amount of maintenance and activity during the outage periods generally contributes to a rise in the number of events.

6|2 Evaluating each site

Belleville-sur-Loire

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

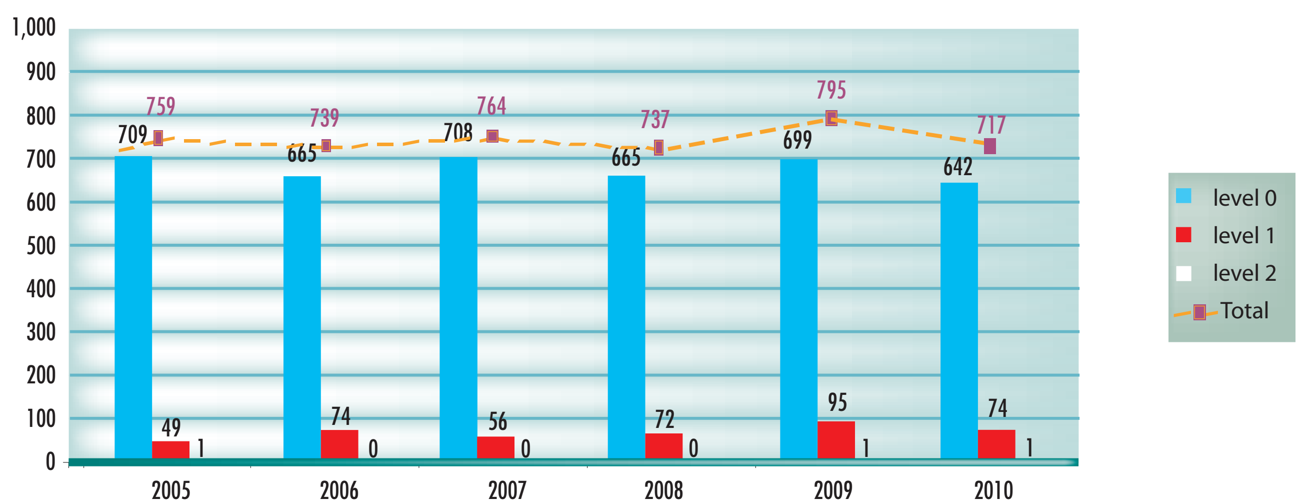
ASN notes a significant improvement on the site in the area of maintenance. Technical and documentary anomalies recorded are now handled correctly and the site draws benefit from feedback at each outage, so as to make progress in maintenance of its installations. However, system alignment errors recorded and significant events that still occur during restarting confirm the need to pursue efforts on stringency in operation.

In the area of environmental protection, the organisational improvements recorded are heavily outweighed by the numerous anomalies still observed. However, ASN notes that the actions under way help to significantly limit their gravity for and impact on the environment.

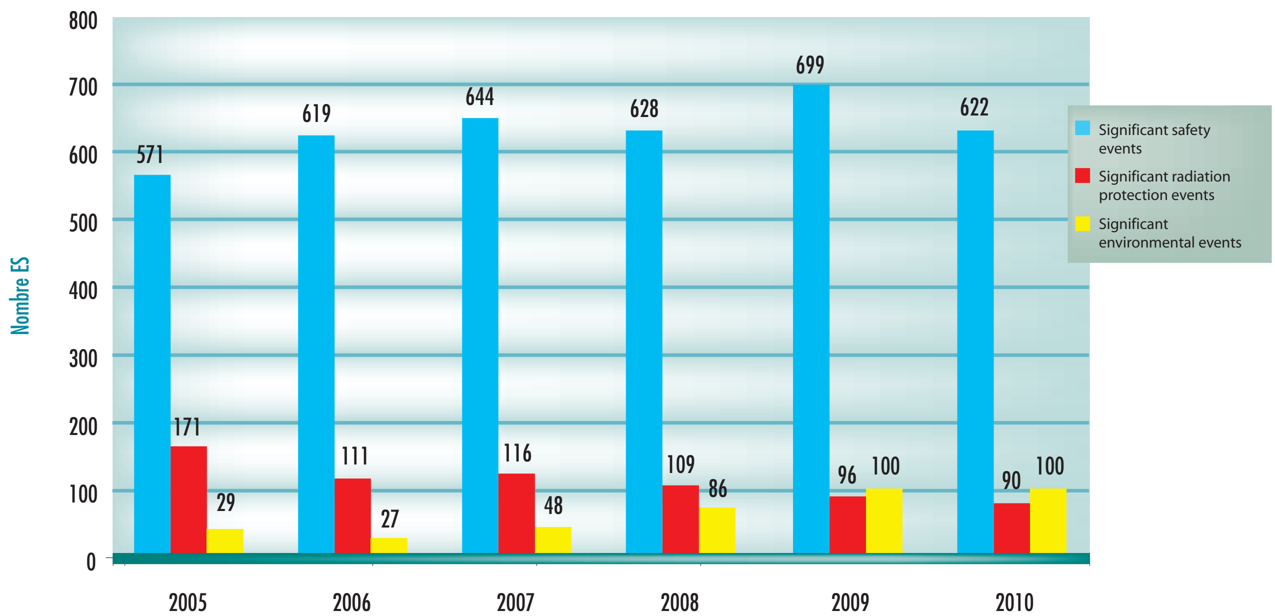
Le Blayais

ASN considers that the nuclear safety, radiation protection and environmental protection performance of the Le Blayais NPP is,

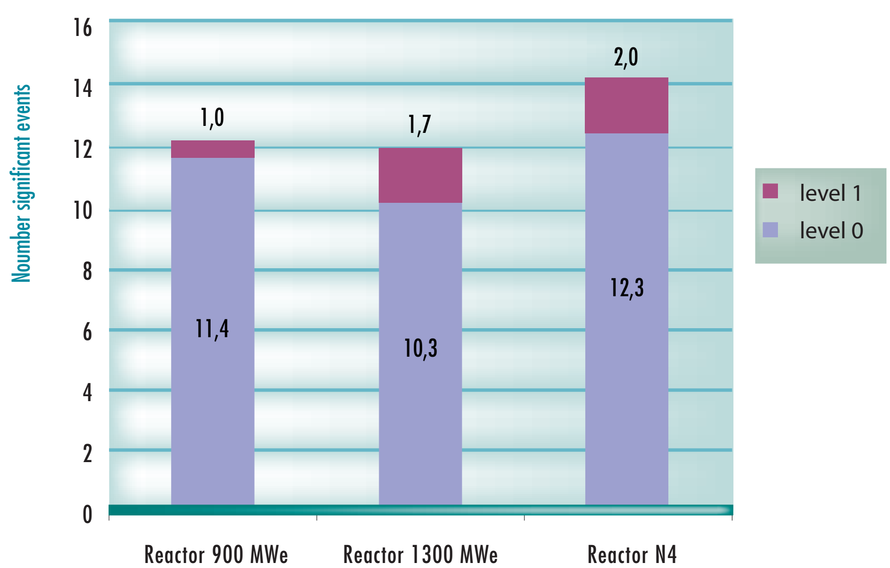
Graph 7: changes in the number of significant events rated on the INES scale in EDF nuclear power plants from 2005 to 2010



Graph 8: changes in the number of significant events per domain in EDF nuclear power plants from 2005 to 2010



Graph 9: average number of INES level 0 and 1 significant events in the EDF NPPs, per type of reactor, for 2010



on the whole, in line with ASN's general assessment of EDF's performance.

ASN has observed significant progress in the carrying out of maintenance operations and plant operation. However, the number of anomalies in application of operating technical specifications remains high and ASN considers that this site should further increase stringency regarding system alignment and preparation of operations, especially regarding the quality and exhaustiveness of risk analyses.

Significant radiation protection event that occurred on 23 April 2010 in the Chinon NPP reactor 4 fuel building

At about 11 a.m. on 23 April 2010, an employee of a contractor company working for EDF was performing a cleanliness inspection of the bottom of the transfer pool in the reactor 4 fuel building for foreign objects. This inspection is required before filling the transfer pool prior to any fuel handling operations. It serves to check that there are no foreign objects that could be entrained into the reactor core during refuelling.

The employee was wearing an impermeable protective garment and vinyl gloves. He was accompanied by another employee who was performing the technical inspection of the activity (and who was wearing the same personal protective equipment).

During the inspection, a metal object was found on the bottom of the pool. The employee performing the cleanliness inspection picked it up with one hand, then held it in his other hand to look at it. Alerted by the triggering of the audio alarm of his operational dosimeter, he threw the object into a bucket used to lower tools from the top of the pool. It was noted that the dosimeter alarm of the employee performing the technical inspection was not triggered.

The bucket was raised to the top of the pool by a third person whose dosimeter alarm was activated in turn. The work site was then evacuated and the workers left the controlled area. The employee who had touched the object with his hands was examined by the plant's occupational physician and to date displays a normal clinical profile.

A reactive inspection carried out in the Chinon NPP by ASN on 3 May revealed the plant's difficulties in establishing a precise record of the facts and a lack of coordination in the post-accident analysis. Several organisational malfunctions and three significant deviations were notified to the licensee.

ASN confirmed the classification of the event as level 2 on the 7-level International Nuclear Event Scale (INES), because a worker was irradiated on the hand, and the dose received exceeded the associated regulatory annual limit.

Lastly, ASN feels that the site must maintain vigilance in the area of radiation protection and strengthen support and oversight in the field, in order to return to the good results of 2009, especially regarding the control of orange zones and radiological cleanness.

Bugey

ASN considers that the Bugey site stands out positively with regard to its nuclear safety, performance in relation to ASN's general assessment of EDF's performance. In particular, the Bugey NPP has an independent safety structure that is strong and is well positioned within the site's organisation.

However, the quality of operation in 2010 showed signs of weakness in the area of system alignments, lock outs and compliance with the technical operating specifications.

In 2010, ASN noted deterioration in the conditions of occupational safety. ASN is expecting some real actions in this area in 2011, a year characterised by a large amount of maintenance activities.

In the areas of radiation protection and protection of the environment, ASN considers that the site's performance is in line with ASN's general assessment of EDF's performance. The efforts under way on the Bugey site for several years are beginning to produce results.

Cattenom

ASN considers that the performance of the Cattenom NPP in the area of nuclear safety, radiation protection and protection of the environment is satisfactory on the whole and is in line with ASN's general assessment of EDF's performance. In particular, ASN considers that the actions undertaken on the site in 2010 have led to progress in radiation protection of workers and should be pursued.

In the fight against legionella, ASN notes that the experimental treatment of make up water did not reach an industrial scale outcome and will ensure that the site continues its efforts in this area, by integrating all of the safety, environmental protection and public health issues.

In addition, ASN considers that the Cattenom site should be more rigorous in its management of transport of radioactive materials as several anomalies occurred in 2010, including the shipping of radioactive waste in unsuitable packaging, an event rated at level 1 on the INES.

Chinon

ASN considers that the Chinon NPP is under-performing in terms of nuclear safety and radiation protection and that the site's environmental performance is, on the whole, in line with ASN's general assessment of EDF's performance.

ASN considers that there is a lack of rigour in operation, characterised again in 2010 by a considerable number of significant events. Analysis of the anomalies reveals weaknesses in both reactor operation and system alignment. In ASN's view the site needs to make progress on knowledge of the general operating rules and compliance with procedures.

Where radiation protection is concerned, the two significant incidences of abnormal exposure of workers to ionising radiation that occurred in 2010 revealed important shortcomings in the preparation of operations. ASN considers that integration of the risk of handling irradiated objects and of the procedures for prior mapping needs to be greatly improved.

Chooz

ASN considers that the Chooz B NPP is under-performing in terms of environmental protection and that the site's performance regarding nuclear safety and radiation protection is, on the whole, in line with ASN's general assessment of EDF's performance.

The licensee at Chooz was confronted with a number of maintenance related incidents that often implicated the preparation of activities or even the competence of the maintenance teams. Where operation is concerned, ASN noted that alignment errors had been virtually eliminated in 2010. In addition, the year was also marked by distortion of assemblies, difficulty with fuel handling operations and jamming of control rods.

In the area of environmental protection, ASN considers that the licensee has not fully integrated the decisions made in 2009 regulating discharges. Several events involving failure to comply with these regulations were reported. The site will have to make progress in this area in 2011.

Civaux

ASN considers that the Civaux NPP's radiation protection performance stands out positively and that its nuclear safety and environmental protection results are, on the whole, in line with ASN's general assessment of EDF's performance.

ASN considers that the site should improve maintenance of its equipment as shortcomings here can have environmental impacts.

Where reactor operation is concerned, ASN notes that conducting of periodic tests is improving, but the Authority considers that the site needs to be more rigorous during the preparation of operations.

Civaux's radiation protection results are good, notably with a low collective dose. ASN emphasises that, for the first time, the EVEREST approach (entering limited access areas wearing ordinary overalls) was implemented in a reactor building throughout an outage.

Cruas-Meysse

ASN considers that the Cruas-Meysse NPP's nuclear safety, radiation protection and environmental performance is, on the whole, in line with ASN's general assessment of EDF's performance, notably because of the plan to improve safety that has been implemented since 2008. However, the site needs to be far more vigilant in order to ensure long-term improvements to the stringency of its operation of the plant.

In the area of radiation protection, the Cruas-Meysse site reported contrasting results in 2010. ASN considers that the results obtained in the area of gammagraphic inspections are satisfactory, but that results are not satisfactory where control of access to orange radiological zones is concerned.

Lastly, where environmental protection is concerned, in 2010 ASN observed weaknesses in the running of projects relative to the setting up of new installations with implications for the environment.

Dampierre-en-Burly

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

However, in 2010, ASN once again detected shortcomings in the overseeing of maintenance contractors. In addition, despite the actions that have been under way in this area for several years, problems arising from anomalies in system alignment persist. ASN considers that these two areas should be priorities for action in 2011.

Where radiation protection of workers is concerned, ASN once again observed an absence of improvement in the integration of requirements on the practices of people coming onto the site. As of 2011, the site should make progress concerning control of contamination and compliance with the essential radiation protection rules.

Fessenheim

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

However, ASN considers that the site must remain vigilant with regard to worker occupational exposure and must take adequate steps.

The ten-yearly outage of reactor 1, which took place from October 2009 to March 2010, showed that the condition of the installations, and in particular of the containment barriers, is satisfactory. At the time of writing ASN is examining the results of the inspections conducted during the outage and will forward its opinion on the extended operation of reactor 1 to the government in 2011. The ten-yearly outage of reactor 2 will also take place in 2011. The steam generators will be replaced on that occasion, making a further contribution to improving the condition of the installations.

Flamanville

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

The site is continuing application of a programme intended to improve safety performance, recentred around clear and targeted objectives that correspond to the shortcomings identified by ASN for several years. The shortcomings relate more specifically to organisational problems, inadequate steering of actions to improve safety, a large maintenance backlog and failures in the area of safety culture.

ASN considers that there have been positive developments in several areas since the middle of 2010. These improvements remain fragile and the programmed periods of reactor outage should allow the site to consolidate its results in 2011.

Golfech

ASN considers that the Golfech NPP's radiation protection performance stands out positively and that its nuclear safety and environmental protection results are, on the whole, in line with ASN's general assessment of EDF's performance.

In spite of results that are satisfactory overall, in 2010 ASN observed some loss of stringency during some operations. There were also some shortcomings in the preparation and carrying out of some maintenance operations during two reactor outages.

ASN considers that the site crews should pay greater heed to events that could have environmental impacts.

In the area of radiation protection, the collective dose is satisfactory and the Golfech plant carries out fuel handling phases in ordinary overalls, without oversuits, a sign of good control of contamination at source.

Gravelines

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

However, ASN considers that the site should look for ways to improve rigour and reliability of some operations. In addition, several events that could have impacted nuclear safety or security were not handled appropriately by the site. In particular, ASN requested temporary shutdown of reactor 2 to remedy incorrect adjustment observed on a steam take-off line for which seismic resistance was no longer guaranteed.

As in 2009, ASN considered that the site should reinforce the means for dealing with environmental protection issues, given its size and location in a dense industrial environment.

Nogent-sur-Seine

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's performance but that it is under-performing in the area of environmental protection.

In 2010, reactor 2 was shut down for around 3 months as part of the ten-yearly outage and the determining inspections for safety were satisfactory. Conversely, several significant events were reported after excursions from the authorised operating range (reactor control) and following system alignment errors during reactor outage.

In addition, ASN considers that the site's results remain satisfactory in the areas of radiation protection, pressure equipment and transport of radioactive materials.

Paluel

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

The site confirmed its progress in the areas of quality of maintenance operations and post maintenance testing of equipment. A reduction in the number of maintenance quality faults was also observed. The site has also implemented a new maintenance strategy intended to improve equipment reliability. In addition, new major investments in the installations have had a positive impact in the areas of safety, radiation protection and environmental protection.

However, ASN considers that the stringency of control operations should be a priority for action and that the staff safety culture should be strengthened since, in spite of much work undertaken, anomalies with regard to operating requirements persist.

Penly

ASN considers that the Penly NPP's nuclear safety performance stands out positively in relation to ASN's general assessment of EDF's performance and that its results for protection of the environment and for radiation protection are on the whole, in line with ASN's general assessment of EDF's performance.

The site is continuing the positive developments of previous years and ASN's inspection did not reveal any particular difficulty in the areas of nuclear safety, radiation protection or protection of the environment.

However, ASN is of the opinion that organisation of the inspection department recognised as being in charge of implementation of pressure equipment inspection plans remains weak. This point is the subject of special attention on the part of ASN.

Saint-Alban

ASN considers that, overall, the Saint-Alban NPP is under-performing in relation to ASN's general assessment of EDF's performance. In 2010, the structural weaknesses already identified in 2009 were observed again, notably during the outage of reactor 2 for reloading.

Since mid 2009 the site has been implementing a plan for more rigorous operation. ASN has noted an upswing in the way safety requirements are affirmed.

In the areas of radiation protection and environment, the site's results remain fragile, these issues not being integrated with sufficient rigour.

ASN notes that where monitoring of pressure equipment is concerned, the recognised inspection department must establish its authority more firmly.

In addition, in 2011, ASN expects progress from the Saint-Alban NPP in terms of its responsiveness and communications with ASN.

Saint-Laurent-des-Eaux

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

In the area of safety, the progress recorded on oversight of the control room has allowed the site to improve management of transient phases of reactor shutdown and restarting. However, ASN considers that the site must remain vigilant in order to ensure the long-term viability of the results and must strive to strengthen the preparation of operations.

ASN notes that the resources implemented by the site have made it possible to reduce the number of significant radiation protection events. Although the radiological cleanness indicators remain at a satisfactory level, the efforts on integration of issues relating to radiation protection by operatives must be maintained.

Tricastin

ASN considers that the nuclear safety performance of the Tricastin NPP stands out positively in relation to ASN's general assessment of EDF's performance. ASN notes that, even if there is still room for progress, in particular in the preparation of operations, plant operation was carried out with greater rigour in 2010, as a result, notably, of the greater involvement of management.

Where radiation protection and protection of the environment are concerned, ASN considers that the site's overall performance is in line with ASN's general assessment of EDF's performance. Specifically, in the area of radiation protection, ASN has observed an improvement in radiological cleanness, especially during reactor outages but also noted a lowering of the site's performance in the area of compliance with radiological zoning.

Lastly, ASN considers that the safety of workers deteriorated badly in 2010, notably with three serious occupational accidents.

Nouveaux réacteurs

6 | 3 Evaluating EPR construction

After inspections carried out in 2010 and examination of the anomalies reported by EDF, ASN considers that, where civil engineering is concerned, the organisation of EDF and the main contractor Bouygue is satisfactory overall and that, in relation to previous years, there has been progress with technical and documentary stringency. Conversely, for new activities such as mechanical or electrical assembly, ASN has noted that, in general, EDF has not adequately anticipated the difficulties of companies in adapting to the requirements associated with application of the government order of 10 August 1984, including prior identification of quality related activities and compliance with all of the associated requirements.

Management of quality associated with construction

During these inspections, ASN noted that the organisation put into place in the various EDF departments in charge of monitoring was on the whole satisfactory. Anomalies were nonetheless observed relating to identification of quality related activities and errors in the traceability of monitoring actions carried out by EDF. Regarding activities inspected in 2010, these errors are, essentially, concentrated around the design engineering practice to which EDF entrusted the monitoring of the detailed design studies for civil engineering and manufacture of systems and components not forming part of the nuclear steam supply system. ASN also considers that EDF should improve its control system for documents used for manufacture of systems, structures and components.

HOF in new reactor projects

ASN sought the opinion of the advisory committee for reactors (GPR) regarding the principles of organisation and the human resources planned by EDF for operation of the Flamanville EPR. This opinion was to be given in December 2010. However, the results of the first series of tests carried out on simulator in 2010 were not conclusive where certain essential elements of the safety case were concerned. They are therefore to be completed by another series planned for 2011, with the GPR's opinion being given in 2012.

In addition, in 2010, ASN also examined the integration of HOF on the Flamanville 3 EPR construction site. ASN considers that HOF specialists should be called on more systematically, for example to develop HOF monitoring guidelines intended for works supervisors and to help the supervisors put them into practice. ASN pinpoints as a positive step the ergonomic analyses conducted in different work situations by the main civil engineering contractor. Where interventions by foreign workers are concerned on the site, particular attention must be paid to there being enough interpreters and to their degree of fluency in French.

With a view to preparing the examination of the application for commissioning of the installation, ASN inspected the organisation of the first pre-operating phase. This is the phase of progressive takeover of the NPP prior to its commissioning. ASN has noted the desire on the part of the future operating team to put in place an organisation that is able to anticipate and which is in line with the "learning organisation" concept: this would take the form of integration of the weak signal detection approach, of the presence of human factor consultants and the setting up of a local network of human factor correspondents. ASN has, nonetheless, asked the licensee to, at the earliest opportunity, take the steps required to guarantee a level of quality that is in compliance with the order of August 1984 for carrying out of current or future actions and that relate to application of the order.

7 OUTLOOK

With regard to NPPs, ASN's regulatory and inspection duties in 2011 will be primarily concerned with the subjects presented below:

7 | 1 Regulation of the EPR and actions relating to new reactors

Regulation of the EPR reactor

Surveillance of construction of the Flamanville 3 EPR will continue until authorisation for commissioning of the installation. ASN intends to pursue its regulatory duties in the areas of prevention of occupational accidents, surveillance by EDF of the quality of work for both works on the construction site and manufacture carried out by its suppliers, notably by means of equipment testing. At present, EDF is planning to submit a commissioning application for its installation in 2012, for initial operation at nominal power in 2014. At the same time, ASN will also be continuing with an early review of certain aspects of the regulatory commissioning application file, in particular the accident study methods, the principles of control and general operating rules. In addition, in December 2010, EDF submitted an application for authorisation to create a reactor of the EPR type at Penly. In 2011, ASN, with IRSN's support, will undertake examination of the file submitted by EDF with the intention of stating its opinion on the authorisation for creation of this new reactor.

Other actions relating to new reactors

In 2011, ASN will, with support from IRSN and the advisory committee for reactors (GPR), examine the safety options for the ATMEA-1 reactor, and will state its opinion on the options. This examination will take place within the framework and according to the procedures of the three-party agreement signed mid-2010 between ASN, IRSN and the ATMEA company.

Furthermore, subsequent to the statement by WENRA published in November 2010 on the safety objectives for new reactors, ASN will contribute to actions aiming to promote these objectives in the worldwide thinking on these subjects initiated by the IAEA or within the MDEP framework. Moreover, ASN will continue to work within WENRA on the development of common positions on subjects resulting from these safety objectives and that warrant clarification.

7 | 2 Oversight of subcontracting

ASN will initiate a process of evaluation of the subcontracting policy, to verify that EDF maintains an adequate internal volume of skills to be able to meet its responsibilities. In addition, ASN will carry out a series of targeted inspections to check that regulations are complied with in subcontracted tasks and the link with conditions for awarding contracts, for both operating installations and on the Flamanville 3 EPR construction site.

7 | 3 Occupational health and safety inspection

Subsequent to the anomalies on sites observed in 2010 relating to exceeding of maximum working hours, ASN will maintain its monitoring in this area. It will see that EDF undertakes real actions in the area of working hours of management staff, the group most concerned. It will also make efforts to disseminate the measures established in the Ministry of Labour's action plan for occupational health and safety inspection, thereby placing the emphasis on health and safety at work, the quality of the work experience, labour relations and governance and combating illicit employment. Lastly, to foster an integral vision of safety, ASN's occupational health and safety inspectors will be associated with ASN's other regulatory activities, notably those concerning subcontractors. ASN will also make a detailed analysis of the conditions of access to the reactor buildings with the reactor in operation, which have caused site CHSCTs to be alerted to a "serious and immediate hazard" on several occasions. ASN will examine the risks inherent to these operations, including the risk of exposure to neutrons and the psycho-social risk. Analysis will be made jointly by ASN's radiation protection and occupational health and safety inspectors.

7 | 4 Radiation protection and protection of the environment

Radiation protection

ASN expects of EDF that it will strengthen its radiation protection policy with, notably, greater raising of awareness of safety culture amongst personnel and progress in controlling of contamination at source. The Authority will be attentive to compliance on these different aspects in the files it will examine, and during on-site inspections. In particular, ASN will carry out a major inspection on the four sites in the Val de Loire region (Belleville, Dampierre, Saint-Laurent-des-Eaux and Chinon), with the intention of producing an in-depth review of the radiation protection actions and to ensure that feedback on events at Chinon 2010 has been taken into account.

Environmental Protection

ASN will apply itself to checking in the field that the actions planned by EDF to fight against legionella, as well as actions to reduce refrigerant emissions, are actually implemented on the different sites. It will also continue its discussions with the licensee on optimisation of emissions, in line with the actions recommended by the GPR in 2009, when it met to examine the question of chemical effluents from operating French NPPs.

7 | 5 Hazard prevention

Preventing fires and explosions

After the transformer fires that occurred in the Paluel and Tricastin NPPs in 2010, ASN decided to carry out reinforced inspections to verify the adequacy of servicing and maintenance of these items of equipment.

Flood prevention

In 2011, ASN will submit the draft guidelines on protection of BNIs against external flooding to the advisory committees for reactors, laboratories and plants. The guidelines constitute the outcome from a working group that, between 2006 and 2009, brought together ASN, IRSN, nuclear industry operators and experts in hydrology.

7 | 6 Surveillance of equipment and maintenance

In 2010, EDF informed ASN of its intention to change in the near future to a new maintenance doctrine, known as AP913. This methodology was developed by the Institute of Nuclear Power Operations (INPO), with the American licensees in 2001. ASN will closely monitor the implementation of this new doctrine.

7 | 7 Review of safety associated with ten-yearly outage

In 2011, ASN will pursue attentively examination of the safety reviews of NPPs that are associated with the ten-yearly outages. 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 Authority will, one year after the end of each ten-yearly outage, make known its opinion on the compliance of each installation with the applicable safety requirements and, if necessary, will prescribe technical requirements to provide a framework for continued reactor operation. Accordingly, in 2011, ASN will state its position after the ten-yearly outages in 2010, notably for the Fessenheim 1 and Bugey 2 reactors which have completed their third ten-yearly outage.

7 | 8 Continuing operation beyond 40 years

As EDF has indicated its desire to extend the duration of operation of its reactors significantly beyond 40 years, ASN will pursue its examination of possible conditions for extension of their operation. To this end, in 2011, ASN, with IRSN's support, will ask the GPR to assess EDF's proposed study and work programme with a view to extending reactor operation. For ASN, extension of reactor operation can only be envisaged if it is associated with a proactive and far-reaching programme for improved safety that is in line with the safety objectives adopted for new reactors and with best international practice.