



**IRSN**

INSTITUT  
DE RADIOPROTECTION  
ET DE SÛRETÉ NUCLÉAIRE

*Enhancing nuclear safety*

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# Annual report 2018

MEMBER OF

**ETSON**

EUROPEAN  
TECHNICAL SAFETY  
ORGANISATIONS  
NETWORK

# ENHANCING NUCLEAR SAFETY, IN FRANCE AND ABROAD

Further to Act No. 2015-992 of August 17, 2015 on energy transition for green growth, the legislative part of the French Environment Code defines the missions of the French Institute for Radiological Protection and Nuclear Safety (IRSN), the public expert in nuclear and radiological risks, together with those of the French Nuclear Safety Authority (ASN), and of the local information commissions (CLI). Decree No 2016-283 of March 10, 2016 on IRSN, which implements the Act, places the organization under the joint supervision of the Ministers for Ecology, Defense, Energy, Research and Health. IRSN is the national public expert in nuclear and radiological risks, and its activities cover all the related scientific and technical issues in France and in the international arena. Its work therefore concerns a wide range of fields, including environmental monitoring, radiological emergency response, radiation protection and human health in normal and accident situations, prevention of major accidents, and safety and security of nuclear reactors, plants, laboratories, transportation, and waste. It also carries out assessments in the nuclear defense field. In addition, IRSN contributes to government policy on health, nuclear safety, the environment and emergency response. Within this context, it interacts with all the organizations concerned including public authorities, in particular the nuclear safety and security authorities, members of the French parliament and local elected officials, research organizations, and stakeholder associations. IRSN also contributes to training and providing public information about nuclear and radiological risks.

## HUMAN RESOURCES



**1,777\***  
employees  
(1,800 in 2017)



**49**

Doctors or persons  
qualified to direct  
research  
(47 in 2017)

**76\*\***

doctoral students  
(81 in 2017)

**10\*\***

post-doctorate students  
(6 in 2017)

## BUDGET



**€ 274 M**  
revenue  
(€ 280 M in 2017)



**39.1%**

of budget devoted  
to research (excluding  
Feurs project)  
(39.8% in 2017)



**51%**

of budget allocated to technical  
support and public service  
missions (excluding Feurs project)  
(50.7% in 2017)

\* This workforce consists of 1,636 persons on permanent contracts and 141 on fixed-term contracts (including 56 persons assigned to other organizations, but excluding 22 temporary assignments)  
\*\* Expressed in full-time equivalent terms (FTE worked)

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# MARIE-FRANCE BELLIN

## Chairperson of the Board of Directors



IRSN's Board of Directors was re-elected in 2018, and I had the honor of being appointed chairperson. I took up the position and the responsibilities it entails several months ago, and I now have a clear vision of the broad scope and complexity of the nuclear safety and radiation protection challenges to be tackled by IRSN.

IRSN must be prepared for the major challenges to come in the short and medium term. **The first is research**, which has been receiving a diminishing share of the total budget in the last few years. The challenge here will be to develop an ambitious research policy to ensure the credibility and independence of IRSN's judgment, and thus to maintain its high level of expertise. The recent recommendations made by The High Council for Evaluation of Research and Higher Education (Hcéres) should help to reinforce IRSN's research strategy. An important element of this will be the development of partnerships, particularly with the academic world.

**The second area is expert assessment**, where there are major challenges in terms of nuclear safety and security, particularly with the new EPR plants, follow-up on the experience feedback from Fukushima and the measures taken at French nuclear power plants, extension of the operating life of nuclear power plants, and the Cigeo project. The same applies to the new security challenges for facilities and for the transportation of radioactive materials, particularly cybersecurity and protection against malicious acts. Finally, the disposal of medium- and high-level long-lived waste is a major challenge, with multiple needs for nuclear but also geological and ethical expertise, given the long life of this waste.

**The third challenge is medical radiation protection** and the increase in uses of ionizing radiation for both diagnosis and treatment.



**IRSN must be prepared for the major challenges to come in the short and medium term.**

A rise in the number of radiology procedures, particularly CT scans, has increased the population's exposure to ionizing radiation at low doses despite uncertainty about its harmful long-term effects. The use of CT scans is becoming increasingly common, especially in emergency medicine and for assessing the spread of many diseases, including cancers. Advances in treatments prolong patients' life expectancy and therefore increase the number of examinations. The rapid development of interventional radiology to guide surgery or replace it can also cause irradiation of patients and operators. Improvements to radiotherapy equipment mean that very dense radiation can be delivered to very precise areas, and this demands trained, careful staff.

**The fourth challenge is maintaining IRSN's attractiveness** to new recruits, especially young engi-

neers, in a highly competitive context of economic recovery. To do this, IRSN must make its expertise shine and promote the excellence of its research in France and abroad.

**The fifth challenge is dialog with civil society** to respond to the public's growing demand for information and involvement in decision-making. A deliberate policy of sharing information and knowledge with a variety of audiences (communities living near nuclear power plants, doctors, associations) is essential. This permanent interaction with civil society is an important component of being alert to risks. It helps to ensure that assessment of nuclear and radiological risks is as robust as possible, so that these risks can be managed appropriately and transparently in view of the challenges and expectations of different sectors of society.

In view of this context, I am particularly focused on ensuring that IRSN has sufficient resources to remain innovative and agile, and to develop research that reflects the scale of its ambitions, because this is necessary to maintain high levels of safety and radiation protection. I am also focused on preserving IRSN's human resources, which are vital to maintaining its role as a driving force in the governance of nuclear and radiological risk.

With the signature of the Performance Target Agreement 2019-2023, IRSN's objectives and resources have been reaffirmed; they enable IRSN to consolidate its commitment to the governance of nuclear and radiological risk.

On a more general level, I find that IRSN's values reflect the values I have held throughout my career in hospitals, values that we will be working on with the Director General:

- the value of collective expertise, which progresses through the work and commitment of people from many different horizons. I have a firm belief in transversality and multidisciplinary, which are essential in hospitals and are also in place at IRSN;
- the importance of research, which safeguards progress and opens up new avenues to explore. It is our collective responsibility to boost research and particularly to increase the number of partnerships;
- the value of teamwork, using teams to deliver excellence for patients in hospitals and for the public in IRSN's case, and education for the young;
- transparency and openness to society, towards patients and their families in hospitals, and towards the public in IRSN's sphere of activity, where there is a high level of demand for information and explanation;
- international openness in order to showcase the expertise of French institutions, benefit from different experiences and forge potentially useful links.



**I find that IRSN's values reflect the values I have held throughout my career in hospitals.**

As chairperson of IRSN's Board of Directors, I am keen to work with the supervising ministries and the Director General, Jean-Christophe Niel, to accompany the changes required at IRSN that will enable it to cope with these new challenges, and to meet the need for information expressed by the public and for technological transformation as digital technologies develop.

We need to give particular attention to education and to sharing information with the general public, as IRSN has done since its creation. In a context of rapid change in modes of communication, particularly due to social networks, we must be attentive to IRSN's duty to provide information laid down by the decree of March 10, 2016. This decree also provides for the creation of a research policy committee to advise IRSN's Board of Directors on the objectives and priorities for IRSN's research into nuclear safety and radiation protection. This multidisciplinary committee, created in 2009, now has an official mandate, and I will take care to ensure it plays its role fully and contributes to the excellence of IRSN's research.

As a public expert in nuclear and radiological risks, excellence, anticipation, independence and sharing will be IRSN's guiding principles for the coming years; it will be an honor for me to follow them and they will guide everything I do.

# JEAN-CHRISTOPHE NIEL

## Director General



In a context of current and future challenges for energy, health, research and security, and demands from the public for transparency and environmental democracy, the Performance Target Agreement signed on January 10, 2019 sets IRSN's strategic orientations and reflects its commitments for the 2019-2023 period to exhaustively fulfill its missions of nuclear safety and security and protection of human health and the environment from ionizing radiation by meeting the expectations of the government and society.

**I want to start by mentioning some key elements of the context to which IRSN's expertise and research responds.**

The multiyear program for energy will cause changes in the nuclear facilities landscape with the arrival of new projects (EPR, Cigeo, RJH, central storage pool, etc.), the management of the existing fleet (continued operation of reactors beyond 40 years, follow-up of the Fukushima accident, safety reviews), and issues related to the dismantling and cleanup of decommissioned civil and military facilities and to radioactive waste management.

The goals of the National Health Strategy 2018-2022 as regards ionizing radiation are to improve the quality and relevance of healthcare procedures, reduce public exposure to substances harmful to health, and assess their combined effects.

Another feature of the current context is the increasing level of expectation from society, particularly in terms of the environment, health and safety, as shown by IRSN's annual Barometer. An accurate knowledge of the environmental impact of activities that use

ionizing radiation or cause public exposure and the monitoring of these activities are therefore vital.

In parallel, there is growing demand for public involvement in decisions regarding the management of risks to health or the environment. From a legislative and regulatory point of view, the national system for the governance of nuclear and radiological risks has been significantly strengthened in the last few years with the Act on energy transition for green growth, the transposition of the European directive on basic safety standards for radiation protection, and the reinforcement of security measures for nuclear facilities and transport and, on a broader scale, the Sapin II Law and the requirements it introduces regarding transparency, combating corruption and modernization of economic life.

In research, as well as universities and research organizations pooling their scientific forces and strengthening their partnerships, which are the key to scientific excellence, the government has begun work on a proposal for a multiannual research orientation and programming law. In this changing and demanding context, IRSN's Performance Target Agreement for 2019-2023, signed on January 10 by

our supervising ministers, is an important milestone in IRSN's governance. This Agreement enables us to share IRSN's strategic orientations and main objectives with our supervisors and the other institutions we have regular contact with, particularly the safety and security authorities. The four chosen strategic areas reflect the various tasks we do: expert assessment, research, monitoring and functional tasks. They enable us to establish a picture of the challenges to be addressed by IRSN in the short and medium term.



**The Performance Target Agreement, signed on January 10, 2019, sets IRSN's strategic orientations and reflects its commitments for the period 2019-2023, meeting the expectations of the government and society.**

**Providing the government and other public authorities with effective assessments and expertise to prevent nuclear and radiological risks.**

IRSN supports the civil nuclear safety authority, ASN, and the nuclear safety authority for defense, DSND, the Senior Defense and Security Officials of the Ministries for Energy and Industry, and more generally, any government departments dealing with nuclear or radiological risks. This support usually takes the form of technical notices and reports (more than 800 in 2018), and sometimes field visits to carry out radiological surveys of sites or environmental characterizations. We demand that these activities are carried out to a high standard, are technically relevant, are proportional to the issues at stake and are performed promptly, whether they are scheduled or impromptu, e.g. in response to an incident. One of IRSN's particular characteristics is its ability to offer scientific expert assessments performed collectively. These rely on the knowledge, skills and know-how of its experts and on feedback from experience. These assessments are conducted in a wide variety of technical fields, so IRSN needs high levels of transversality and a strong multidisciplinary culture. These expert assessments require innovation in terms of methods and knowledge, so that new problems and situations can be handled. For this reason IRSN investigates new fields such as multicriteria analysis methods and research into augmented expertise and the use of artificial intelligence.

Nationally, IRSN makes a technical contribution to various government policies and national plans related to radiological and nuclear risk management. On this basis it contributes to the National Health Strategy, the Health and Environment Plan, the Radon Plan, the Occupational Health Plan, the Radioactive Materials and Waste Management Plan, and the Cancer Plan.

At European and international level, regulatory requirements are usually developed by dedicated bodies such as Euratom, the IAEA, UNSCEAR and the ICRP. The definition of common objectives and the harmonization of expert assessment practices help to ensure a uniform approach is taken by national systems for the governance of nuclear and radiological risks. Among these organizations, I would particularly like to mention the European ETSON network (European Technical Safety Organisations Network), the network of IRSN's European counterparts engaged in this harmonization process. More generally, IRSN participates in the dissemination and promotion of French approaches to safety and radiation protection with in these international bodies.

**Deploying the scientific strategy and conducting high-level research by promoting the development of national, European and international networks to meet the challenges of expert assessment.**

The research conducted by IRSN is designed to make available the knowledge IRSN needs to conduct expert assessments as part of its appraisal of nuclear and radiological risks.

It receives effective support from its Scientific Committee, Inspection Committee and Research Policy Committee.

It meets the requirements for scientific excellence and the sharing and dissemination of knowledge, as shown by the conclusions of the Hcéres audit in 2018. In a context of sustained demand for expert assessments, one of IRSN's challenges is to make sure it maintains a balance between expert assessment and research.

Research partnerships, which guarantee scientific quality and efficiency, can be a means of enhancing capacity and streamlining resources. It is therefore vital for IRSN to play a leading role in structuring and programming research activities nationally, at European level and internationally. IRSN actively participates in the creation of consortia for research projects bringing together French organizations and their foreign counterparts, global academic players and, where appropriate, industry. To support these research projects, we have the benefit of first-class experimental facilities that contribute to the production of the data needed to achieve advances in knowledge. These facilities also lead to the development of partnerships.

In the radiation protection field, IRSN has platforms for radiation measurement, irradiation and microscopy. In the nuclear safety field, the platforms cover a wide spectrum of topics such as fire, containment, material aging, thermal hydraulics and radiochemistry.

I would like to pay tribute to the work done in 2018 to complete the first test on the pressurized water loop in the Cabri reactor, a CEA facility made available to IRSN. This reactor is used to develop programs to study the behavior of nuclear fuel in accident situations.

### Contributing to transparency and dialog on nuclear safety and radiation protection.

Since its creation, IRSN has developed a policy of openness to society, which has been written into successive performance target agreements with the government. This policy consists of sharing the scientific and technical knowledge resulting from IRSN's work and encouraging society to make a contribution to our research and expert assessment activities.

In the context of the Act on Transparency on Nuclear Safety, IRSN is already in contact with key players such as the local information commissions (CLI), their national association (Anccli) and France's High Committee for Transparency and Information on Nuclear Safety (HCTISN). Stakeholders' expectations and questions are changing; IRSN must therefore continue working to make scientific information, and knowledge more generally, available and to share that information and knowledge. For example, it is helping to bring clarity to the public debate on France's National Radioactive Materials and Waste Management Plan by making available its scientific and technical assessments and its know-how on dialog with society and on the development of a radiation protection culture within populations affected by measures to prevent radon exposure in homes.

In the last few years, IRSN has begun to involve civil society representatives in the review of files with major safety implications, particularly in the context of the fourth periodic reviews of the 900 MW reactors and the defects found in the steel used for the closure head domes of the EPR reactor at Flamanville.

To ensure this technical dialog on nuclear and radiological risks becomes a regular event, IRSN intends to set up a diverse representation body, a committee for dialog between elected officials, stakeholder representatives, industry, government representatives and IRSN's experts. This body will complement the work of the Research Policy Committee, which was set up to make recommendations to guide IRSN's research, taking society's expectations into account.

### Adapting IRSN's support for authorities and government departments to cope with the changing nature of nuclear and radiological emergencies.

Nuclear and radiological emergencies require an all-encompassing response from the government that covers. They need strong coordination between the different national and regional agencies involved, and also with European and international authorities. IRSN provides operational support to the government and other public authorities in this context, by mobilizing its expert assessment capabilities and by activating its Emergency Response Center and its monitoring and response capabilities. IRSN is identified in the national emergency response plan for major nuclear or radiological accidents, and is therefore called upon to contribute to improvements in the national response system for radiological emergencies and post-accident situations. In liaison with the public authorities, it also does the same for the NRBC plan.

### Running IRSN responsibly.

IRSN is covered by the government's policy of modernization and public spending control. As part of this, we have to improve risk management and performance without jeopardizing safety, and to promote the financial sustainability and efficiency of the Institute's activities. More generally, I want to pursue a policy of social and environmental responsibility by increasing IRSN's everyday actions on social and environmental matters, ethics, transparency, etc. In particular, a new Ethics Commission was appointed in 2018.

The Performance Target Agreement sets out the ambitions for IRSN, in response to the expectations of the government and society.

I am determined to follow this road map, working closely with the Board of Directors and its Chairperson, Marie-France Bellin.

The women and men at IRSN, whose commitment and professionalism in what they do are widely recognized, will also be committed to its deployment.

# LOUIS-MICHEL GUILLAUME

Deputy Director General in charge of Defense-related missions



In the field of defense, security and non-proliferation, the signature of the Performance Target Agreement 2019-2023 in January reaffirmed the challenges for IRSN. In particular it set two objectives:

- to conduct expert assessments concerning the security of nuclear materials, facilities and transport and to undertake the associated operational missions.
- to contribute, in support of the authorities responsible for them, to France's compliance with its commitments regarding nuclear non-proliferation and the ban on chemical weapons.

These objectives illustrate the diversity of IRSN's missions and its commitment to advancing nuclear safety and security in the defense arena, and nuclear security for civil facilities and transport.

In 2018, as part of its technical support to the Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities (DSND), IRSN examined the measures associated with the return to operation of the *Charles de Gaulle* aircraft carrier following a major technical shutdown, reviewed the preparations for the core embarkation and criticality of the *Suffren*, the Barracuda program's first nuclear-powered attack submarine, including its support infrastructure in Cherbourg, Brest and Toulon, conducted a review prior to the commissioning of the RES reactor at Cadarache, and continued to work on the safety review of nuclear-powered ballistic missile submarines in service and their support facilities on land. For the facilities run by the CEA and Orano on behalf of the DSND, IRSN examined the chosen strategy for the dismantling and cleanup of facilities and for managing the associated waste and effluent.

  
In the field of defense, security and non-proliferation, the signature of the Performance Target Agreement 2019-2023 reaffirmed the challenges for IRSN.

As part of its activities for the Senior Defense and Security Official (HFDS) at the Ministry of Energy, IRSN assessed the files related to the implementation by nuclear facility operators of the draft decree on the protection and control of nuclear materials, facilities and transport (decree No 2009-1120 of September 17, 2009) which aims to tighten requirements for the protection of existing facilities from malicious acts and terrorism. Recurrent technical support and assistance has been provided, particularly under the inspection program for facilities and transport defined by the HFDS' departments.

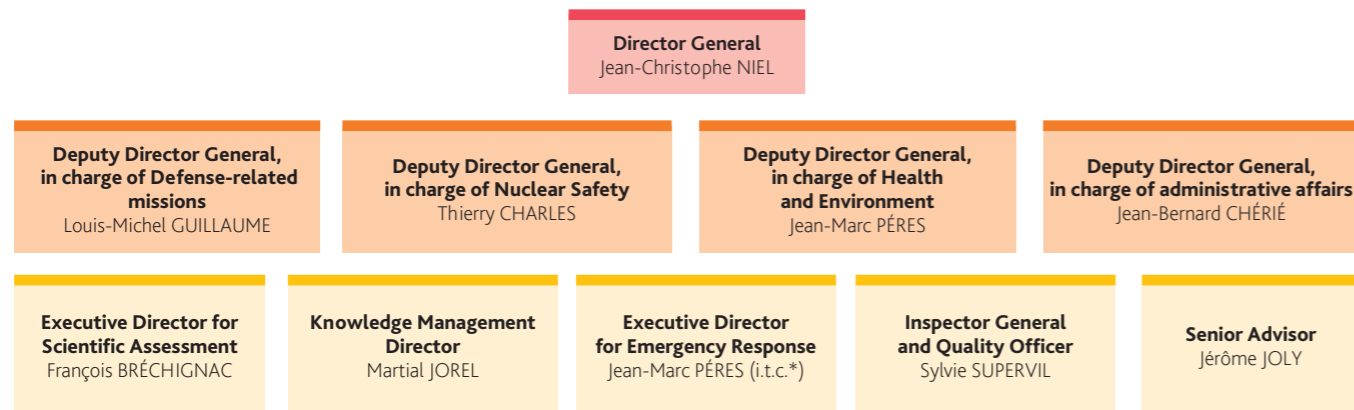
Finally, in 2018 IRSN continued to provide technical support and assistance for France's application of international treaties on nuclear non-proliferation (Euratom Treaty, IAEA Safeguards Agreement, bilateral agreements) and banning chemical weapons (Chemical Weapons Convention). To do this it collected and forwarded the licensees' declarations to the inspection bodies and accompanied international inspections carried out by the IAEA and Euratom for nuclear non-proliferation and the OPCW for chemical weapons.

This sustained activity continues in 2019 with, in the case of naval propulsion, the start of work on the future nuclear-powered ballistic missile submarine, the first tests on

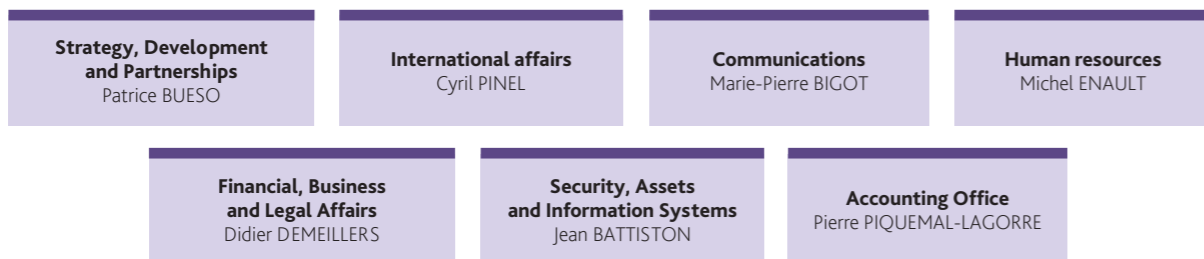
the *Suffren* nuclear-powered attack submarine in Cherbourg, and the withdrawal from service of the *Saphir*. In parallel, the review of protection measures against malicious acts at French operators' industrial sites will continue, in particular looking at the future central storage pool, currently at the design stage. Finally, IRSN will provide technical support to administrations involved in major international events such as the review conference of the non-proliferation treaty and the International Atomic Energy Agency's international conference on nuclear security.

# GOVERNANCE

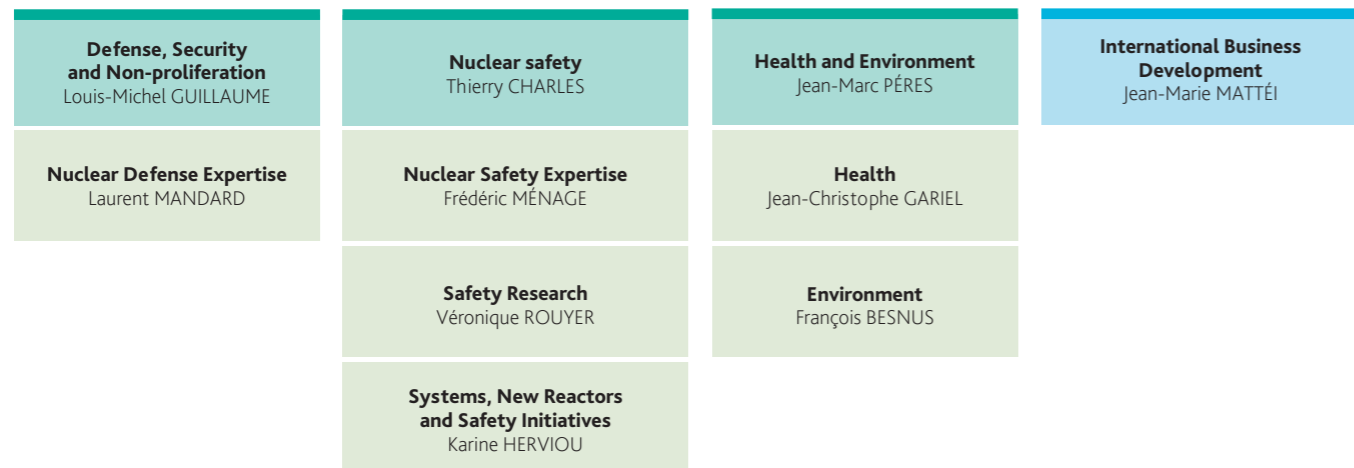
## ORGANIZATION CHART AS OF FEBRUARY 1, 2019



### FUNCTIONAL AND SUPPORT DIVISIONS



### OPERATIONAL DIVISIONS



\* in temporary capacity

## SENIOR MANAGEMENT COMMITTEE AS OF FEBRUARY 1, 2019

**Jean-Christophe NIEL**  
Director General

**Louis-Michel GUILLAUME**  
Deputy Director General,  
in charge of Defense-related missions

**Jean-Bernard CHÉRIÉ**  
Deputy Director General,  
in charge of administrative affairs

**Thierry CHARLES**  
Deputy Director General  
in charge of Nuclear Safety

**Jean-Marc PÉRES**  
Deputy Director General  
in charge of Health and Environment

**François BRÉCHIGNAC**  
Executive Director for Scientific Assessment

**Martial JOREL**  
Knowledge Management Director

**Patrice BUESO**  
Director of Strategy, Development  
and Partnerships

**Marie-Pierre BIGOT**  
Director of Communications

**Cyril PINEL**  
Director of International Affairs

**Michel ENAULT**  
Director of Human Resources

**Jérôme JOLY**  
Senior Advisor

**Sylvie SUPERVIL**  
Inspector General and Quality Officer

## EXECUTIVE COMMITTEE AS OF FEBRUARY 1, 2019



Louis-Michel GUILLAUME • Sylvie SUPERVIL • Jean-Christophe NIEL • Cyril PINEL • Frédéric MÉNAGE



Jean-Marie MATTÉI • Didier LOUVAT\* • Patrice BUESO • Martial JOREL • Pierre PIQUEMAL-LAGORRE



Marie-Pierre BIGOT • Thierry CHARLES • Jean BATTISTON • Jean-Marc PÉRES



Jean-Christophe GARIEL • Didier DEMEILLERS • Karine HERVIOU • Jérôme JOLY • François BESNUS



Jean-Bernard CHÉRIÉ • Michel CHOUHA\*\*



Michel ENAULT • Véronique ROUYER • François BRÉCHIGNAC • Laurent MANDARD

\* ENSTTI  
\*\* Riskaudit

# STRATEGIC ORIENTATIONS

## A NEW ROAD MAP FOR THE COMING YEARS

A year of evaluating past achievements and looking ahead, 2018 was the last year of the Performance Target Agreement 2014-2018 between the French state and IRSN, and the year in which its implementation during that period was assessed. 2018 also saw the preparation and approval of a new Agreement for the period 2019-2023. This important task of reflection on the governance documents benefited from the assessment of IRSN by the High Council for Evaluation of Research and Higher Education (Hcéres) and the internal IRSN 2030 initiative, and involved many of the Institute's staff and its institutional partners.

### REPORT ON THE PERFORMANCE TARGET AGREEMENT 2014-2018

The Performance Target Agreement 2014-2018 between the French state and IRSN came to an end in 2018, and was evaluated in a report in preparation for the next agreement. A key element of IRSN's governance, the Performance Target Agreement 2014-2018 focused on three main areas:

- maintaining world-class research to advance nuclear safety and prepare the expert assessment capability of tomorrow;
- effectively deploying the know-how and resources necessary to assess and prevent nuclear and radiological risks;
- increasing openness towards a society increasingly concerned about nuclear and radiological risks.

These strategic areas serve as the basis for defining operational targets in IRSN's fields of activity, i.e. safety, nuclear security and non-proliferation, human and environmental radiation protection, emergency response and aspects related to post-accident situations.

In the 2014-2018 period, expert assessments by IRSN played a key role in the management of major national issues, including:

- the review of the operating license application for the Flamanville EPR;

- the safety assessment of the future geological disposal facility for nuclear waste;
- the review of the compliance of nuclear facilities with the new requirements for the protection and control of nuclear materials;
- efforts to improve the performance of the radiation protection system and, in particular, to enhance knowledge of human and environmental exposure to ionizing radiation, including in the field of medical applications;
- development of policies and improvement of national organizations responsible for radiological or nuclear emergency response.

In parallel, IRSN also performed expert assessments in a large number unscheduled cases with major safety implications, requiring a high degree of responsiveness from IRSN's teams, e.g. on carbon segregation in the closure head domes of the EPR reactor at Flamanville and in the steam generators of reactors in operation, and on the strength of the dike at the Tricastin nuclear power plant.

IRSN's research activity was sustained, with the development in 2015 of the scientific strategy for the next 10 years and

participation in European (Euratom H2020) and national projects (Investments for the Future program). These projects in particular enabled the research identified following the Fukushima-Daiichi accident to be pursued in greater depth. IRSN's commitment to research was highlighted by Hcéres in its evaluation.

Having the ability to conduct experiments, whether analytical or integral, is vital to guarantee the standard of the targeted research carried out by IRSN. Consequently, for the 2014-2018 period, IRSN focused on the deployment of large experimental infrastructure, particularly in the field of radiation protection, with the Mircom facility, which can perform irradiation at subcellular level, the MICADO-LAB irradiator for studying the effects of ionizing radiation on plant and animal species, and the PARISII platform for studying the effects of chronic exposure through internal contamination with various different radionuclides, including uranium, cesium and strontium.

### In brief

#### Appointment of IRSN's new Ethics Commission

— IRSN's new Ethics Commission, which now has seven members, met for the first time on October 5, 2018. Working alongside the Board of Directors, the Ethics Commission is a consultative body responsible for advising IRSN on drafting codes of ethics applicable to its various activities and for monitoring their application. In particular it monitors the separation maintained within IRSN between its expert assessments performed for government departments and those performed as a commercial service. A review is planned in 2019-2020 of IRSN's implementation of its Code of Ethics and Professional Conduct adopted in 2013 and its Charter on Openness to Society signed in 2009.

As regards openness to society, IRSN was active in three main areas:

- the transparency of its expert assessment work, which became a requirement in 2015 with the energy transition act for green growth, through the publication of IRSN's opinions where these are not related to defense;
- building skills within society, leading to technical discussions on technically complex subjects: continued operation of the 900 MW reactors beyond their 40-year life, carbon segregation problems in the closure head domes of the EPR reactor, waste disposal, etc;
- taking account of stakeholders' concerns in research programs, with the work of IRSN's Research Policy Committee, stakeholder involvement in putting together European projects, etc.

Finally, in line with the government's modernization policies, IRSN is continuing to work on improving its governance and management, in particular by managing changes in its skills pool, managing its technical resources, and improving its procurement performance and budgetary management.

#### MAIN ORIENTATIONS OF THE PERFORMANCE TARGET AGREEMENT 2019-2023

The draft Performance Target Agreement for the 2019-2023 period was approved by the Board of Directors on December 4, 2018 and signed by the supervising ministries on January 10, 2019. It was based on discussions held from February 2018 onwards with representatives from the supervisory ministries, safety and security authorities and the administrations to which IRSN provides technical support.

The draft contains the following objectives:

- maintaining the quality of IRSN's expert assessment by providing operational support to the public authorities, contributing to public policy development and deployment and to the promotion of French approaches to safety and radiation protection among our foreign counterparts, particularly within the ETSO network;
- deploying the scientific strategy and conducting high-level research, by encouraging the emergence of partnerships, promoting IRSN's experimental platforms, and strengthening ties with the academic world;
- permanently establishing and developing the policy of transparency and openness to society, by supporting the building of skills within civil society, contributing to a regular dialog with stakeholders and taking account of their expectations in IRSN's research orientations;
- adapting the support it gives to the authorities and government departments to cope with changes in the nature of nuclear and radiological emergency situations, by developing a response capability for NRBC emergencies and by reinforcing its action on post-accident situations;
- running IRSN responsibly, by ensuring its governance and management is consistent with government modernization policies, by reinforcing its technical and financial management, by managing knowledge and developing skills, and by pursuing a socially and environmentally responsible policy in relation to the management of its human and financial resources and its assets.

The objectives set out in the Performance Target Agreement reflect the French state's expectations of IRSN and also IRSN's desire for excellence, independence, anticipation and sharing, pursued by the IRSN 2030 initiative.

### ZOOM

#### DRAFTING OF THE MEDIUM-TERM PLAN

Alongside the preparation of the Performance Target Agreement 2019-2023 and in response to the themes and objectives set out in it, IRSN has drawn up the Medium-Term Plan 2019-2023. This document explains the activities and resources planned by IRSN for research and expert assessment, and for its functional and support missions.

It is based in particular on documents describing the expert assessment challenges in the next 10 years for reactors, laboratories and plants, and on research approaches breaking down IRSN's scientific strategy by theme. These approaches, which were finalized in 2018, were based on recommendations made by the Scientific Council and the Research Policy Committee. Contextual information such as the results of scientific assessments, preparation for the ninth European framework program for research, and the closure of France's national 'Nuclear Safety and Radiation Protection Research' program were also taken into account when planning the research actions.

With regard to expert assessment, IRSN will be involved in dealing with the major national nuclear safety and security and radiation protection issues: the central spent fuel pool project; the Cigeo disposal facility; extension of the life of 900 MW reactors; the EPR reactor; the ITER project; the new generation nuclear-powered ballistic missile submarine; dismantling decommissioned facilities; nuclear facility security and the fight against cybercrime; and preparation for radiological and nuclear emergencies.

Based on the assumption that public funding will be maintained at 2018 levels for the next five years, achieving a balance between research and expert assessment activities will require a more efficient use of funds, which means controlling the way they are structured and spent, pooling resources, and making the most efficient use of IRSN's platforms in the context of structuring and strategic partnerships.



# SCIENTIFIC EXCELLENCE

For its research, IRSN is developing a strategy based on acquiring and developing knowledge, and on comparison with other practices. Its participation in national, European and international networks enables it to make best use of the practices and work of other organizations it collaborates with and to promote its priorities for the orientation of research programs. By sharing its experience and methods and disseminating the results of its research, IRSN also opens up opportunities to promote its platforms more widely within the scientific community.

## A STRONGER SCIENTIFIC AND TECHNICAL PARTNERSHIP WITH THE CEA

Based on the research needs expressed by IRSN and the CEA in safety and radiation protection, the desire expressed in 2017 to strengthen the scientific partnership between the two bodies aims to broaden the scope of their knowledge acquisition by leveraging the complementary aspects of their teams and sharing their existing and planned research resources and infrastructure more extensively. The first exchanges, which took place in 2018 with the joint organization of two science days, also reflect their desire to jointly promote their research teams within the European radiation protection and environmental research arena. A radiobiology colloquium at the end of January 2018 brought together 150 participants from the CEA and IRSN to discuss the main research programs being run in this field. The colloquium was run under the aegis of France's High Commissioner for Atomic Energy and the Director General of IRSN, and followed an internal CEA/IRSN call for proposals aimed at increasing collaboration and supporting joint project development. Two collaborative projects received special funding as a result of this and are helping to boost partnerships between teams at the Fontenay-aux-Roses site, which hosts the main radiobiology teams of the CEA and IRSN. The first will analyze the mechanisms that cause the persistence of breaks in the two strands of DNA subject to ionizing radiation. The second should characterize the contribution of a recently identified type of mesenchymal stem cell, known as a MUSE cell, to the treatment of a gastrointestinal syndrome caused by intense irradiation of the intestinal area, for which no effective treatment is available.

A second science day was organized in September on the impact of radionuclides in the environment. It gave teams working in the field of environmental science, including radioecology and radiotoxicology, the opportunity to gain a clearer picture of the areas of common interest and the complementary knowledge, know-how and tools held by the two bodies. A closer relationship between the teams should raise the profile of their work within Europe, looking ahead to the transition to the ninth European research and innovation framework program.

## EVALUATION OF IRSN BY HCERES

The High Council for Evaluation of Research and Higher Education (Hcéres) published its evaluation report on IRSN as a research establishment. This evaluation looked at IRSN's strategy, organization and governance of its research.

### In brief

#### Boost for ANR and PIA projects

Two new projects involving IRSN were awarded funding by the ANR in 2018. The DISRUPT project aims to improve the analysis of ruptures of faults observed on the Earth's surface following an earthquake, in order to detect a link with the earthquake characteristics, which would open up new perspectives in terms of seismic hazard. The IXBONE project aims to find strategies for bone regeneration in cases of facial bone hyperplasia following radiotherapy treatment of cancer of the upper airways or digestive tract.

In particular Hcéres highlighted IRSN's identity, which is strong both internally and externally, its high profile and international recognition, and its active participation in structuring European research. It also mentioned IRSN's policy of openness to society, which creates a climate of trust with its partners. The report also made recommendations, such as strengthening its partnerships with the academic world, developing a more assertive institutional profile in the national and international research arena, and achieving better governance of IRSN's activities in this area. These conclusions are an endorsement of IRSN's commitment to research but also the changes it has begun to make to its strategic orientations, organizational structure and the way it works. Important actions in recent years, particularly the release of its scientific strategy and the development of documents setting out its approach to research by theme, have

## ZOOM



Employment outcomes for doctors leaving IRSN, 2007 to 2015 cohorts, by type of contract and situation (%). The key on the right shows in color the time elapsed since they defended their thesis and specifies the number of doctors (always 115 in the 2007 to 2011 cohorts). The 2 to 4% 'lost' are not represented separately but are included in the figures.

begun to bear fruit. Although the 'Upgrading functional and support services' project naturally takes into consideration the evaluation's structural recommendations, further targeted action has also been agreed. Accordingly, IRSN is stepping up its policy of promoting its infrastructure through structural partnerships, and a trial of the use of project mode for research has begun, with the implementation of initiatives resulting from the IRSN 2030 call for proposals.

## ASSESSMENT OF TRAINING THROUGH RESEARCH

IRSN takes on and trains doctoral students and post-doctoral researchers 'in and for research' as part of its normal research activities. In addition, IRSN's commitment to its doctoral students includes a special internal training curriculum, the organization of annual 'Thesis Days' specifically for these students, where they present the

progress of their research, and preparation for the period after they complete their thesis. The hundred or so doctoral students and post-docs present at any time of year represent a third of IRSN's researchers (full time equivalent). IRSN's policy of training in and through research also helps to build important links with the academic world. Almost half of the doctoral research is conducted with partner research organizations. IRSN also aims to maintain a high level of employability and therefore tracks the employment outcomes of its former doctoral students and post-docs. Since 2007, out of 225 young doctors leaving IRSN, 90 to 95% had found a job three years later. Of these, 61 to 71% were in permanent employment, which matches the national average according to ministerial surveys (MESRI/SIES and CEREQ).

### In brief

#### Exploratory research to encourage innovation

Three new exploratory research projects began in 2018, and two projects launched 12 to 18 months earlier were completed or were coming to an end. One aims to develop digital tools for modeling microstructural changes in a MOX fuel matrix and also for modeling the release of fission products; the other is looking at the development of new dosimetry approaches suitable for accident situations involving large-scale external exposure. In the last 12 years IRSN has supported more than 30 exploratory research projects in addition to its programmed research, in order to harness its researchers' innovation and creativity.

## ZOOM

### KNOWLEDGE MANAGEMENT: AN OPERATIONAL ACTIVITY FOR THE CIVIL SECTOR

IRSN has launched a knowledge management initiative to give it an overview of the key knowledge it needs currently and in future in order to fulfill its missions. In 2018 its operational network of knowledge management coordinators (CMCs) was completed. The coordinators (there are 26) are responsible for organizing and leading knowledge management activities in their respective units in areas related to safety, health and the environment. To complement previous work, strategic knowledge analyses have continued in the areas of safety of facilities other than pressurized water reactors, and R&D in safety. A review of the strategic knowledge analysis has been launched in the area of the environment. Analysis of the way knowledge is structured means that information databases can be created, to be used for reference. These assets constitute IRSN's store of

knowledge. The database containing information related to the production of safety assessments over more than 40 years has now been supplemented with similar information for health and the environment. The earliest documents are now being added. Capitalization on the knowledge of critical 'knowledge-holders' has led to the production of new 'books of knowledge', notably on the following subjects: 'Non-destructive testing of metals: controls for their simulation'; 'Issues, methods and applications of level 2 probabilistic safety assessments'. All this information has been made accessible internally through the 'knowledge portal', which is the single point of access to all the knowledge produced by IRSN in any subject area. To make it easier to find knowledge within these documentary databases, a special tool has been developed and deployed.

# OPENNESS TO SOCIETY

Listening to public concerns is an essential component of the public debate about risks. In application of its Charter on Openness to Society and its Performance Target Agreement, IRSN is continuing its technical dialog with multiple partners. The aim of IRSN's approach of transparency about its work and sharing of its expertise through a regular dialog with society is to help members of the public to forge their own opinions. Openness initiatives, which have historically concerned the subjects of expert assessments, are now expanding into the field of research. They enable IRSN's experts and researchers to better understand society's questions and concerns, and to take account of them in their expert assessments and research.

## SAFETY ISSUES: INITIATIVES TO GATHER QUESTIONS FROM CIVIL SOCIETY

Joint ANCCLI/IRSN initiatives concerning safety reviews continued to be run nationally in 2018. The fourth periodic reviews of 900 MW reactors pose a particular issue for society because of plans to extend the operating life of these reactors and because of the need to take account of experience feedback from the Fukushima accident. In 2018, Anccli, ASN and IRSN continued their technical dialog, begun in 2017, on the fourth periodic reviews. The main objective of this process is to gather questions from civil society while the three partners examine the themes in question, so that these issues can be addressed as a priority in the dialog. After an initial meeting in 2017 on compliance and aging, two further meetings were held in June on internal and external hazards and on severe accidents and the post-Fukushima hardened safety core.

The 460 questions asked at these meetings were collected and categorized by theme (review process, aging, severe accidents, hazards, compliance, pools, vessels, fuel cycle, containments, objectives, security, transport, human and organizational factors, subcontracting, post-Fukushima, PSAs, etc.). Since September 2018, this process of gathering stakeholders' questions has continued

as part of the public consultation organized under the HCTISN's supervision by EDF, ASN, Anccli and IRSN in the presence of two observers from the French National Public Debate Commission (CNDP).

As part of this public consultation, IRSN is taking part in meetings organized with the local information commissions (press conferences, general information meetings, themed workshops). The first few meetings (the commissions at Dampierre, Bugey, Tricastin, Cruas, Saint-Laurent-des-Eaux and Le Blayais) were very well attended. IRSN aims to answer questions on technical subjects within the scope of its expertise, in its opinions or on the website set up for the public consultation.

## FURTHER DIALOG WITH LOCAL INFORMATION COMMISSIONS

IRSN continues to make its teams and its knowledge available to the local information commissions. In 2018 IRSN received a total of around 50 information requests from the local information commissions, of which around 15 prompted contributions to public meetings or special training courses. IRSN also expanded its network of representatives in the commissions as a result of requests from the Flamanville and Chinon local information commissions, bringing to 10 the number of commissions that have requested permanent support from IRSN.

## In brief

### Involvement in Alliss

IRSN has joined a collaborative project run by the Alliss association, which promotes links between science and society, to start research on chronic exposure and multiple exposure situations. Following a discussion seminar held on May 31 and June 1, research actions are currently being defined. IRSN's participation in initiatives of this kind enables it to try out new forms of research involving stakeholders, and to benefit from their experience feedback so that it can respond more effectively to the challenges facing society.

## LOCAL AND REGIONAL ACTIONS RELATED TO RADON

To develop a closer relationship with civil society, IRSN is developing local and regional actions in Franche-Comté and Haute-Vienne, to complement the national radon management policy, with the aim of demonstrating the effectiveness of action to help residents manage the risk. On the basis of this initiative, IRSN organized a local seminar with all the partners involved, to share experiences from this local radon initiative. Experiences regarding knowledge of the levels of exposure to radon in homes, implementation of appropriate remedial action, and lessons learned in other European countries were explained and discussed to enrich the reflection process for those dealing with the increase in interest in this problem.

## EUROPEAN TERRITORIES PROJECT: A REFLECTION WORKSHOP ON POST-ACCIDENT ISSUES

As part of its international action, IRSN held a themed workshop on managing land after a nuclear accident, organized in conjunction with the Blayais local nuclear information commission and the Nuclear Protection Assessment Center (CEPN). The workshop was held in Bordeaux in December as part of work for the European TERRITORIES research project run by IRSN. This program involving eight European countries aims to develop a graduated, integrated method of reducing uncertainties during decision-making regarding the management of long-term contaminated lands, while taking into account the involvement of all stakeholders. The workshop tied in with one of the themes of the TERRITORIES project to engage stakeholders and take account of their expectations in decision-making processes concerning different situations of long-term exposure to radionuclides. It was one a set of three events organized in parallel, in France, Spain and Belgium, to achieve the objective of comparison between Member States.

Personal testimonies from Japanese and Belorussian speakers involved in restoring living conditions after the Fukushima-Daiichi and Chernobyl accidents enabled French attendees to grasp the scale of the difficulties and challenges for agriculture when faced with a long-term post-accident situation. Having heard these experiences, a panel of local stakeholders met to research the medium- and long-term challenges and socioeconomic uncertainties that they would face, in light of their knowledge of the characteristics of their local area.

## INVOLVING SOCIETY IN ISSUES RELATED TO THE EFFECTS OF RADIOACTIVITY ON HEALTH

As part of its dialog with civil society, in March 2018 IRSN organized a joint discussion seminar with Anccli on the subject of 'Radioactivity and

# 50

requests for IRSN involvement received from local information commissions



Public meeting on December 13, 2018 at Saint-Laurent-Nouan (Loir-et-Cher) as part of the consultation with civil society on the fourth ten-yearly outage inspections of 900 MW reactors.

health: where are we at?'. This meeting followed on from a seminar in November 2015 on radioactivity in the environment and its effects on health. It aimed to pass on to stakeholders knowledge gained through expert assessments and research, mainly conducted by IRSN, so they could form their own opinions about the risks related to radioactivity. In particular the seminar provided an opportunity to discuss the link between radiation exposure and health. It was also a chance to review the results of studies of populations living near nuclear sites and personnel working at these facilities, and to discuss the question of accident and post-accident situations. Two round table discussions enriched the debate: 'Certainties and controversies', and 'Health monitoring: how can it be improved?'. They provided an opportunity for questions about the definition of a dose and its calculation, and about the situation for contractors.

## PREPARATION FOR THE PUBLIC DEBATE ON RADIOACTIVE WASTE MANAGEMENT

Assistance was sought from IRSN as part of preparations for the public debate organized by the CNDP with a view to the drafting of the fifth National Radioactive Materials and Waste Management Plan (PNGMDR). The public debate is scheduled for 2019. IRSN's Director General presented to the chair of the Special Committee for Public Debates (CPDP) the subjects that he felt should be discussed as a priority in this debate. IRSN also contributed to the reflection process initiated by the Committee, explaining the options in the PNGMDR that are a matter of scientific or technical debate.

## ZOOM

### WORK DONE BY THE RESEARCH POLICY COMMITTEE ON POST-ACCIDENT SITUATIONS

IRSN's Research Policy Committee mandated a working group of its own members to examine in more depth questions related to the aftermath of a nuclear accident, in light of experience feedback from the Chernobyl and Fukushima-Daiichi accidents. The working group looked at the medium and long-term consequences, after the emergency phase, and examined all aspects related to the protection of populations, their movements, and living conditions in contaminated lands. Recommendations were made as a result of the work, including making greater use of research, particularly through the presentation of an overall strategy for the research done at IRSN on post-accident situations, and public involvement well before the start of research on post-accident management.



01

## ASSESSING THE SAFETY OF CIVIL NUCLEAR FACILITIES

IRSN's role as an assessor in the field of nuclear safety concerns nuclear reactors, fuel cycle facilities, research facilities and the transport of radioactive material. IRSN issues an assessment of the safety of these facilities and transport, which it submits to public authorities. IRSN also seeks to foster discussion on fundamental issues with civil society.

### FOURTH PERIODIC REVIEW OF 900 MWE REACTORS

In 2018, the assessments conducted for the safety review of 900 Mwe series reactors associated with the fourth ten-yearly inspections (VD4 900) required extensive use of the Institute's assessment capabilities (66 full-time equivalents worked).

In particular, IRSN assessed the measures implemented by EDF to successfully manage the ageing of these reactors and presented its report to the Advisory Committee for Reactors (GPR) and the Advisory Committee for Nuclear Pressure Equipment (GPESPN). It also continued to assess design-basis accident studies, level 1 and 2 probabilistic safety assessments and studies of internal and external hazards as well as severe accident studies, with a view to presenting its conclusions to the GPR in 2019 at the four dedicated meetings. In addition, the in-service performance of 900 MWe reactor vessels between the two ten-yearly inspections was subject to a first review, which was presented to the GPESPN and will be concluded in 2019 by a second assessment. This generally entails assessing the relevance and demonstrative nature of the studies submitted by

EDF, evaluating the adequacy of the changes proposed by EDF with regard to the objectives of the VD4 900 safety review (in particular working towards the safety objectives defined for third-generation reactors), and ensuring that the reactors can continue to be operated over the coming decade.

In 2018, IRSN continued the round of technical dialogue with civil society undertaken in 2017 in partnership with ASN and ANCCLI. This follows on from the work carried out since 2014 on the safety objectives involved in periodic reactor safety reviews. This technical dialogue provides discussions with stakeholders while the technical review is being conducted and before any decisions are made, in order to apprehend the expectations and concerns of members of the local information commission (CLI), associations and non-institutional experts, and support efforts to build their skills in particularly complex areas. After an initial meeting at the end of 2017 on the subject of compliance control and reactor ageing, a second meeting was held

on June 11, 2018 on internal and external hazards. A third meeting took place on June 26, 2018 on severe accidents and the implementation of a hardened safety core following the Fukushima-Daiichi accident.

These discussions are held in parallel with the public consultation on the general phase of the safety review, organized from September 2018 to March 2019 under the aegis of the French High Committee for Transparency and Information on Nuclear Safety (HCTISN), with the support of IRSN.

**66**  
FTE (full time equivalent) employees assigned to the fourth periodic review of 900 MW reactors in 2018

### ASSESSMENT OF SPENT FUEL STORAGE

At the request of the French Parliamentary Committee of Inquiry into the Safety and Security of Nuclear Facilities, IRSN produced a summary report on dry and pool storage of spent fuel assemblies and the associated safety issues in France and around the world. IRSN concludes in this report that the two types of storage do not meet exactly the same requirements: pool storage is required for fuel that has hardly cooled whereas dry storage is suitable for fuel that has cooled significantly. Residual heat must be taken into consideration in the choice of storage type and constitutes the deciding factor from the perspective of safety and the intended storage time, which depends on the chosen fuel cycle. Moreover, storage in pools, generally containing hotter fuel, requires more substantial safety measures than dry storage, for which more passive measures can be implemented. In dry storage, however, cladding (the first containment barrier) is subject to greater thermal stress and is more difficult to inspect.

### DEVELOPING AN EXPERT SYSTEM IN THE FIELD OF FIRE RISK

IRSN has developed a Bayesian network-based expert system (ES) to study the effects of gas pressure as a result of fire in nuclear facilities. Expert systems are computer systems that use artificial intelligence to emulate the decision-making ability of an expert. Expert systems are composed of a knowledge base containing the general information that constitutes its field of application and an observation base that gathers contingent information, based on which new information can be deduced. An inference engine, composed of a set of algorithms, conveys data flows from the observation base through the knowledge base.

The ES developed relies on simulations provided by the SYLVIA software, used to model facility fires and ventilation systems, coupled with the statistical tool SUNSET, which offers a set of data processing methods for risk analysis. Both programs were developed by IRSN. The SE means that extensive databases can be processed almost instantaneously and that a decision-making tool is finally available for assessing fire risk.

### ASSESSMENT OF THE "IMPACT OF THE FUEL CYCLE 2016" FILE

In May 2018, IRSN presented to ASN the conclusions of its assessment of the Impact of the Fuel Cycle 2016 file (*Impact Cycle 2016*) submitted by EDF and written alongside others involved in the nuclear fuel cycle. For each stage of the cycle, the file presents the consequences of EDF's strategy of using different types of fuel in its reactors over the next 10 years.

In its assessment of the file, IRSN noted that, in terms of safety and radiation protection, the impact of current management solutions for reactor fuel and those planned up until 2030 on French fuel cycle facilities and transport does not indicate any major technical issues over this period. However, the measures planned by operators to address the saturation of certain storage facilities (for depleted uranium, spent fuel assemblies, etc.) must be implemented in accordance with forecast schedules. For this file, EDF conducted a study into the risk of fuel cycle facility failure (unavailability for several months). IRSN considered this initial assessment of these risks to the fuel cycle to be satisfactory on the whole, but noted that it needs to be developed further. Furthermore, IRSN highlights the importance of analyzing the consequences of reactor shutdown, in accordance with the energy transition act for green growth, on the operation of the whole cycle, given that the consequences are different depending on the fuel used in the reactors that are shut down.

### P<sup>2</sup>REMICS, A NEW SOFTWARE PROGRAM TO ASSESS EXPLOSION RISKS

In order to assess risks linked to hydrogen during a nuclear reactor severe accident, IRSN has developed a software called P<sup>2</sup>REMICS. For this purpose, IRSN has formed a cooperative network, largely associating French universities and National Center for Scientific Research (CNRS) laboratories. P<sup>2</sup>REMICS simulates the formation of explosive atmospheres, then the deflagration of the reactive mixture of hydrogen and oxygen. Moreover, it can also be used to calculate dust deposition and aerosol transfer, to simulate the interaction of a spray safety system with the containment atmosphere, and to take into account the effect of hydrogen recombiners.

The P<sup>2</sup>REMICS v1.0 code has been put through a verification process consisting of 16 test cases and a validation process using 25 experimental tests. It has already been used in inter-comparison exercises carried out nationally, such as the MITHYGENE project supported by the Investment in the Future Program, and internationally, such as in projects run by the OECD Nuclear Energy Agency (OECD NEA).

### In brief

#### Periodic safety review

IRSN examined the periodic safety review report on Framatome's plant in Romans-sur-Isère intended for nuclear fuel fabrication for research reactors (INB 63). It concluded that the measures chosen for the continued operation of this facility were satisfactory, given the safety improvements implemented or defined in the licensee's action plan and on condition that the actions identified as priorities are carried out on time. IRSN's review also revealed that the analysis laboratory at this INB does not comply with current safety standards. IRSN considers that operation of this laboratory may continue for a limited time considering the improvements made by the licensee – provided that the radioactive inventory is significantly reduced – but that a new laboratory will need to be built in the long run.

**11**  
technical reviews performed to support ASN Advisory Committee meetings regarding safety

### INTERNATIONAL SEMINAR ON CHEMICAL RISKS IN FUEL CYCLE FACILITIES

The international seminar on the safety of fuel cycle facilities, organized by IRSN and the OECD NEA in April 2018, focused on the theme of chemical risks. The main topic for discussion was the safety of processes involving chemicals, particularly the measures taken against criticality risks and risks linked to corrosion, fire or explosion.

The seminar held as part of the NEA working group activities on fuel cycle safety provided an opportunity for in-depth discussions between safety authorities, technical safety organizations (TSOs) and operators based in NEA member countries. IRSN presented its R&D programs on four major subjects relating to spent fuel reprocessing: the risks generated by the formation of red oils; corrosion phenomena in certain industrial systems; radiolysis phenomena; and ruthenium behavior in high-level liquid waste.

Based on these discussions, a series of general recommendations were issued particularly concerning risk assessment (integration of feedback on chemical release; design of a graduated approach to chemical risks by national regulatory organizations; etc.) and measures for managing accident situations (consideration of all the chemicals likely to be released on a site in emergency plans; suitability of detection measures for these substances; etc.).

### MANAGING DISMANTLING WASTE

At the request of ASN and ASND, IRSN reviewed Orano and CEA's strategies for the dismantling of shut down nuclear facilities, including the recovery of legacy waste and management of radioactive waste. Given the large number of operations involved in facility dismantling, Orano and CEA have determined priorities for addressing aspects of safety and radiation protection.

The operations prioritized and the objectives chosen for these strategies (final state, etc.) were reviewed by IRSN, who recommended certain modifications. Furthermore, the Institute looked into the availability of resources required to support these operations (transport containers, waste treatment facilities, etc.). It identified the resources that are critical for prioritized operations.

In particular, IRSN's review of radioactive waste management strategies brought to light issues related to the availability of waste management solutions and the sharing of related resources (waste processing facility at CEA Cadarache (INB 37); liquid effluent treatment station at CEA Marcoule; type B transport containers for solid or liquid waste; etc.). Finally, the review of organizational systems set up by Orano and CEA to successfully dismantle their facilities and manage waste concluded that they are appropriate overall.

### IAEA JOINT CONVENTION ON THE SAFETY OF SPENT FUEL AND WASTE MANAGEMENT

As part of its support to ASN, IRSN participated in the review process planned under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. The objective of the

convention, of which France is a signatory, is to achieve and maintain a high level of safety in this field worldwide.

IRSN contributed to preparations for the Sixth Joint Convention Review Meeting, which was held at the IAEA from May 21 to June 1, 2018. To this end, the Institute analyzed 43 reports submitted by the contracting parties to the Joint Convention, and its experts participated in the debates. IRSN also chaired a group in charge of reviewing the reports of ten of the signatory states.

The meeting highlighted the need for many countries to make progress in implementing disposal programs for spent fuel and high-level waste as well as for sealed sources.



**IRSN's review of Orano and CEA's strategies for radioactive waste management brought to light issues related to the availability of waste management solutions and the sharing of related resources.**



General view of Saint-Laurent-des-Eaux nuclear power plant (Loir et Cher).

### CRITICALITY SIMULATION: CRISTAL MADE AVAILABLE TO THE NEA

The CRISTAL V2.0.2 computational package, used for assessing criticality risks in nuclear fuel cycle facilities and in packages used to transport fissile materials, has now been made available to the OECD NEA.

Fruit of a partnership between CEA, Framatome, IRSN and Orano, the CRISTAL package draws on a large experimental validation database containing the results of nearly 3,000 experiments conducted under various research programs.

By making it available to the NEA, member country organizations will be able to strengthen their collaborative work on the subject of criticality. It also gives industrial operators the chance to use a benchmark tool to support the criticality studies that they are required to conduct as part of their projects in OECD member countries.

### SEISMIC FAILURE OF EMERGENCY GENERATORS

On June 20, 2017, EDF declared a significant safety event, classed Level 2 on the INES scale, due to the possible unavailability of the emergency diesel generators for all 1,300 MWe series reactors. Following inspections by EDF, the declaration was updated to extend it to all of the nuclear reactors at Bugey and Fessenheim power plants in 2017, and to the Saint-Laurent B reactors and reactor 2 at the Chinon B nuclear power plant in 2018.

Given the nonconformities identified, which related to the anchoring of equipment required for correct emergency generator operation, resistance of the generators to a "seismic margin earthquake" (SME) or even a "maximum historically probable earthquake" (MHPE) could not be ensured. In the event of an earthquake, this could have resulted in an interruption in the power supply to the equip-

ment used to cool fuel, as well of a loss of cooling function in spent fuel pools.

IRSN also emphasized the importance with regard to safety of regular monitoring combined with preventive maintenance programs, which should enable such deviations to be detected.

The nonconformities were addressed for all of the reactors affected.

**551**

**technical notices and reports submitted to ASN (excluding defense-related activities)**

### In brief

#### International cooperation

— An IRSN expert participated in the international group appointed by the Swiss Federal Nuclear Safety Inspectorate to assess the consequences of indicated defects resulting from the inclusion of aluminum oxide clusters in the reactor 1 vessel at the Beznau nuclear power plant (Swiss Canton of Aargau). The group concluded that the clusters identified have no negative impact on toughness and mechanical strength under normal or accident conditions.



# 02

## ACHIEVING A HIGH LEVEL OF SAFETY IN FUTURE FACILITIES

IRSN examines the files and general orientations submitted by licensees for new facilities or new transport containers.

### MONITORING PROGRESS OF THE EPR WORKSITE

In July 2018, IRSN presented its conclusions to the ASN Advisory Committee for Reactors on safety analysis report submitted by EDF in 2015, in support of its operating license application for the EPR reactor at Flamanville in Normandy.

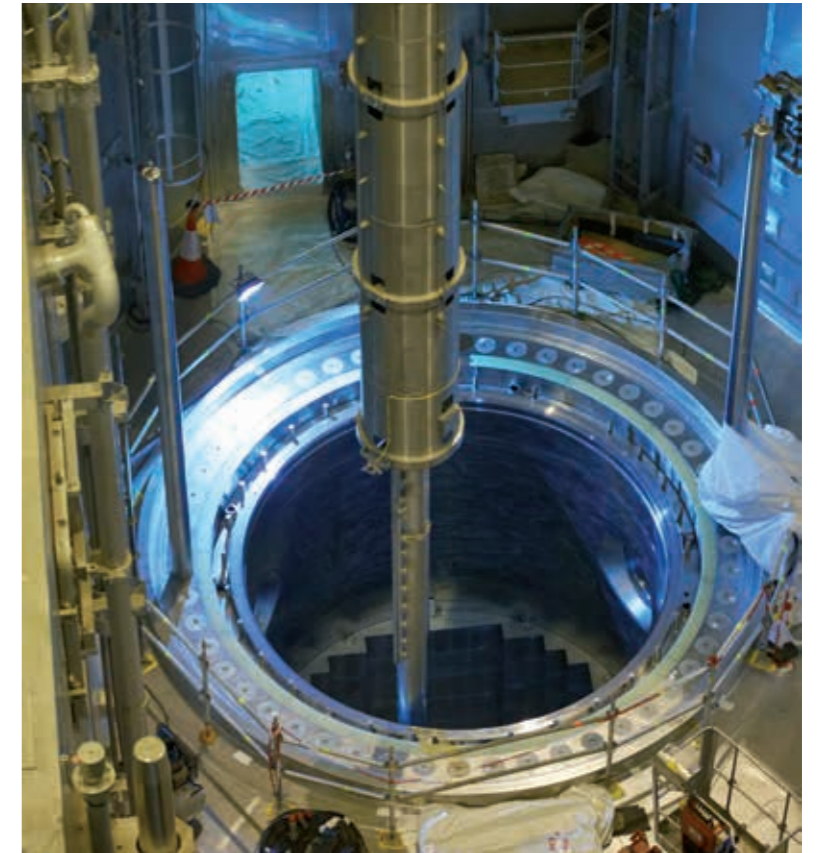
This review focused notably on organization and control resources, severe accident management, safety of fuel handling and storage, accident studies and systems design as well as the provisions made to protect the facility against external hazards. In its review, IRSN did not find any major issues likely to jeopardize reactor commissioning, although additional information is required from EDF, in particular concerning the control of fire risks, the water filtration function in the event of a break in the reactor coolant system and pressurizer safety relief valves.

IRSN also assisted with commissioning tests set up by EDF in order to ensure that the EPR reactor complies with the requirements set up in the safety analysis report. For this purpose, an IRSN expert was present on site during the test phases from March 2017 to January 2018, then occasionally in spring and summer 2018. In particular, IRSN analyzed the test results and the consequences of any deviations likely to affect safety. Discussions on the subject are held with the site on a weekly basis.

Furthermore, following deviations observed on the welds of the main steam lines, various discussions were held with EDF and ASN as part of the analysis of the upgrade program presented by EDF (weld repairs and conducting of tests).

### 23

FTE (full time equivalent) employees assigned by IRSN to the Flamanville 3 EPR assessment.



EPR Flamanville: IRSN follows the on site commissioning tests (above: positioning of the fuelling machine in the reactor vessel)

### REVIEW OF SAFETY OPTIONS FOR THE NEW MODEL EPR

IRSN reviewed the safety options report for the third-generation new-model EPR reactor (EPR NM) project submitted by EDF. At this stage, the choices made by EDF do not call for comment, except for the increase in power: a choice not supported by IRSN insofar as it would result in a reduction in safety margins. IRSN considers that a more in-depth analysis of technological breakthroughs could have been conducted, taking into account experience feedback from EPR reactors. The Institute found that, at this stage in the development of the project, the design options retained by EDF are likely to ensure a safety level for the EPR NM that is at least equivalent to that of Flamanville EPR. It also pointed out that the simplified design makes the facility more constructible and facilitates safe reactor operation. Finally, IRSN has determined several areas that need to be reviewed upstream of any construction license application: design methods for equipment and structures following "severe" earthquakes; protection provisions against fires or explosions, etc.

**A FIRST REFERENCE DOCUMENT FOR NUCLEAR FUSION REACTOR PROJECTS**

IRSN has published a new work in its reference documents series entitled Nuclear Fusion Reactors // Safety and Radiation Protection Considerations for Demonstration Reactors that Follow the ITER Facility. Drawing on IRSN's expertise in safety and radiation protection, and the experience obtained during the ITER safety analysis, this work constitutes a first reference base for or projects to develop nuclear fusion reactors.

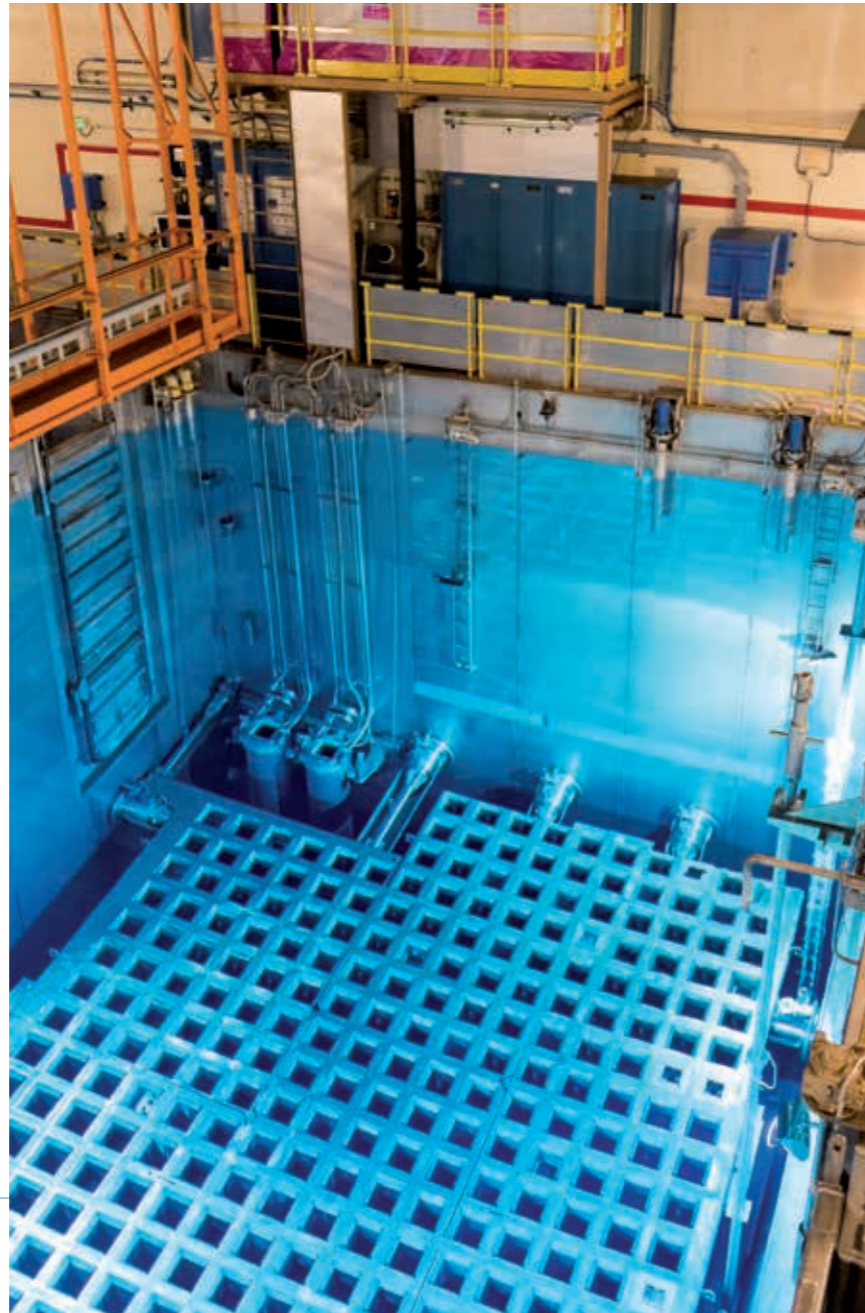
In the report, IRSN details the measures that should be taken into consideration with regard to safety and radiation protection when designing demonstration fusion reactors to be built after the completion of the experimental International Thermonuclear Experimental Reactor (ITER) facility. It was presented at the IAEA general conference.

**EDF CENTRALIZED STORAGE POOL**

At the request of the ASN, IRSN reviewed the safety options report for a centralized storage pool for spent fuel assemblies submitted by EDF in April 2017. In particular, IRSN analyzed the design choices, the safety approach to design and consideration of EDF's objective of operating the facility for around one hundred years.

In this respect, EDF presented measures to reduce the risks associated with hazards (APC shell, semi-buried location, etc.) and loss of cooling. Moreover, the operating life of the facility is one of the criteria used to define the design options.

Given that the storage pool seal system is safety-sensitive area, IRSN considers that EDF should develop its research on this topic in the next stages of the project. Furthermore, as part of defense-in-depth, IRSN has recommended that EDF study the assumption of a leak in a storage pool or a fuel assembly transfer channel that cannot be offset in order to further improve the safety level of the facility.



Storage pool for spent fuel assemblies at the Saint-Laurent-des-Eaux nuclear power plant.

# DEFENSE SAFETY

**SAFETY ASSESSMENTS OF DEFENSE-RELATED ACTIVITIES AND FACILITIES.**

IRSN provides technical support to the Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities (DSND). In the context of this work, IRSN assesses the safety and radiation protection of nuclear facilities and transport within the DSND's scope of activity.

**ASSESSMENT OF THE SAFETY REPORT COMPLETED ON DIVERGENCE AUTHORIZATION FOR THE RES REACTOR**

In May, the Reactor Safety Commission (CSR) met for the seventh and last time as part of the operating license procedure for the RES test reactor. The meeting concluded the review of the intermediate safety analysis report for the RES reactor that IRSN began in 2008. By reproducing the operation of naval nuclear propulsion systems on French submarines and the Charles de Gaulle aircraft carrier, the new reactor will contribute to the qualification of equipment, fuel and computer codes in order to improve their performance and safety level. IRSN's assessment, which explored 45 different subject areas, determined the behavior of three containment barriers in an accident situation and facility resistance to the specific seismic risks at the Cadarache site. Based on this assessment, the Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities (DSND) granted the divergence authorization for the RES reactor.

**ASSESSMENT OF THE DISMANTLING AND CLEANUP STRATEGY FOR THE MORONVILLIERS SITE**

Following the shutdown of activities at the PEM experiment center in Moronvilliers (near Reims), classed as a "defense-related nuclear experimental facility and site" (SIENID), CEA initiated a program to dismantle and cleanup its site.



General view of the Marcoule site (Gard).

Managing the site is complex due to its history: it has been classed as a Zone Rouge (Red Zone) since 1919 on account of the high risk of explosion due to the innumerable unexploded shells in the ground from the First World War.

Responsible for assessing CEA's proposed strategy, IRSN presented its report to the Laboratory, Plant and Waste Management Safety Commission (CSLUD) in March. The assessment of this file with a high social impact should enable the DSND to reach a decision on whether to issue the necessary licenses for the operations planned by CEA. Its conclusions will serve to create a reference base for future cleanup files for French nuclear sites at the end of their life cycle.

**SAFETY REVIEW OF BITUMINIZED WASTE DRUM STORAGE AT THE MARCOULE INBS AND STUDIES FOR THE COMMISSIONING OF NEW MODULES**

The chemical treatment of liquid radioactive waste produced by operations at the CEA Marcoule center generates muds which are concentrated in radionuclides. During the first few decades of site operation, these muds were mixed with bitumen and then poured into bituminized waste drums, which were mainly stored in rooms known as bunkers. The oldest drums were gradually recondi-

tioned into stainless steel overdrums and transported to newer storage facilities pending a final disposal solution. Alongside the safety review of these legacy waste management operations, IRSN contributed to assessing the facilities planned by CEA to replace this mud conditioning method with an embedding process using cementation.

**71** technical notices and reports submitted to ASND



## 03 CONTRIBUTING TO SECURITY AND NON-PROLIFERATION

In line with the missions assigned to it, IRSN provides support and assistance to the public authorities responsible for checking compliance with regulations on the protection and control of nuclear materials, nuclear facilities and nuclear material transport, and to the public authorities responsible for ensuring compliance with the international commitments made by France on non-proliferation of nuclear and chemical weapons.

### NEW PARTNERSHIP IN THE PHYSICS OF EXPLOSIVES

As part of its nuclear security research, IRSN has been conducting test campaigns since 2006 on blast waves and on explosions in semi-confined environments and their effects on structures. A scientific collaboration agreement concluded with the French-German Research Institute of Saint-Louis (ISL) will enable it to take this work further, increase its knowledge and raise its international profile in explosives science.

The ISL, an expert body in explosives science and ballistic protection, has major experimental facilities dedicated to protection technologies. Cooperation between IRSN and the ISL is already reflected in joint experiments and presentations at specialist conferences.

### PLATFORM FOR MONITORING NUCLEAR MATERIALS TRANSPORT

IRSN Transport Operations is responsible for managing and processing applications for authorization to transport nuclear materials, monitoring shipments, and sending the relevant authorities any notifications of such shipments. To meet the French nuclear safety authority's requirements, IRSN Transport Operations has developed an application named SATURNE for sending information securely to various emergency response centers run by the public authorities and for viewing the transportation of nuclear materials within France on a map.

## 114

national inspections related to protection and control of nuclear materials

## 47

inspections of organizations in possession of nuclear materials

## 45

technical checks on approved equipment for transportation of nuclear materials

## 22

transportation inspections

## 104

technical notices submitted to the MTES Senior Defense and Security Official

## 97

technical notices sent to the CTE and the economic and finance ministries responsible for non-proliferation

## 49

missions to escort inspections involving international nuclear material control (including complementary access visits)

## 9

missions to escort international inspections involving the chemical weapons ban

### In brief

#### COMUHREX 2

— At the request of the Senior Defense and Security Official (HFDS) of the Ministry of Ecological and Inclusive Transition, IRSN analyzed the assessment of vulnerability to malicious attack for the "Philippe Coste" Comurhex 2 uranium conversion plant. As a result of this analysis, the HFDS authorized the possession and use of the nuclear materials required to start up the Philippe Coste plant at the end of 2018, for the benefit of the George Besse 2 uranium enrichment plant.

#### REVIEW OF THE SECURITY OPTIONS FOR THE EPR NM

In parallel with its examination of the Safety Options Report, IRSN reviewed, on behalf of the Senior Defense and Security Official (HFDS) of the Ministry for Ecological and Inclusive Transition, the security review preparation file (DOSec) submitted by EDF for the Gen III EPR NM reactor. IRSN also examined the security design approach and the protection options chosen to address the various design basis threats listed in the national security directive.

#### CONTRIBUTION TO WORK ON THE SECURITY OF SOURCES

Regarding the security of radioactive sources, as part of the transposition of Directive 2013/59/Euratom by the HFDS of the Ministry of Ecological and Inclusive Transition and the ASN, IRSN provided technical support for the drafting of the orders implementing the transposition decree. These orders introduce new technical and organizational requirements to improve the protection of radioactive sources against malicious acts and to combat illicit trafficking of sources.

For the European ITRAP+10 program (Illicit Trafficking Radiation Assessment Program), IRSN assessed the performance of equipment for detecting and identifying radioactive materials, to be used for checks at borders and when entering and leaving buildings. To do this, IRSN developed two test benches and, under normal and degraded conditions, conducted more than 3,000 tests with around thirty sources. The results will guide the changes to requirements that may be recommended by the EU.

#### ENHANCED SKILLS IN CYBERSECURITY

Nuclear facilities increasingly use computerized systems for their control, safety and protection from malicious acts. Assessment of their cybersecurity is therefore vital. IRSN contributes to this by giving technical support in this area to the HFDS of the Ministry of Ecological and Inclusive Transition (MTES) when it examines the files submitted by licensees. Expert assessment of the files of many licensees helps to consolidate IRSN's skills. IRSN also develops its expertise and improves the quality of support it gives to the public authorities through practical case studies.

For this purpose, IRSN began the first tests on certain communication protocols with vulnerabilities that could be exploited by a cyberattacker. IRSN also met industry representatives and potential partners for future collaborations, particularly with a view to setting up a platform to simulate complex IT systems at IRSN, integrating information systems used in industry (HYDRA project).

### + SUSTAINED INVOLVEMENT IN THE IAEA'S ACTIVITIES

As nuclear expert and technical support provider on the Euratom Technical Committee (CTE), IRSN contributes to the IAEA's activities in the area of Safeguards. The IAEA is tasked by the 189 signatory States to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) with controlling nuclear materials, activities and facilities throughout the world, and works to ensure they are not diverted for military purposes. To this end, the IAEA concludes legally binding Safeguards Agreements with the States, often accompanied by an additional protocol giving it enhanced powers of inspection.

IRSN's involvement in this enabled France to play a particularly active role in 2018 with the IAEA, which sees cooperation from the States as a means of enhancing the effectiveness of its action.

- o In keeping with its participation in the additional protocol signed between Euratom and France and transcribed into French law in 2016, IRSN contributed on an interministerial basis to the drafting of the implementing decree issued in October. This decree sets out the obligations placed on French industry and the access conditions for the IAEA in France during "complementary" access visits where only 24 hours' notice is given.

- o As part of its technical support role for the CTE, IRSN was involved in accompanying IAEA inspectors during the two complementary access inspections carried out for the first time in France by the IAEA, one in March at the Cadarache Center for the

CABRI program, and the other in October at the Saclay Center for the ASTRID program. In both cases, IRSN was able to ensure both that national interests were protected and that France met its international commitments.

- o IRSN also gave four talks at the IAEA's Safeguards Symposium, held every four years. In particular, IRSN presented the latest progress with tools developed for the additional protocol and for tracking imports and exports of nuclear materials. These tools enable France to meet its obligations towards the IAEA in these areas.
- o Lastly, IRSN assisted industries affected by the implementation of a small quantities protocol at French sites in the Caribbean. This means that France will be able to send the IAEA the required data as soon as the protocol comes into force, which is expected to be in early 2019.

In 2018 IRSN contributed to the IAEA's activities on Safeguards



IRSN participates in the work of the Organisation for the Prohibition of Chemical Weapons (OPCW).

#### SUPPORT FOR THE OPCW

France is heavily involved with the organizations working to combat the proliferation of weapons of mass destruction, in particular the OPCW, which is responsible for enforcing the Chemical Weapons Convention (CWC). By virtue of its duties, IRSN provides technical support to the French authorities responsible for implementing the CWC in the civil sector nationwide.

In 2018 IRSN offered special support to the OPCW under the mentorship program, an initiative launched by the OPCW within its assistance activity to developing Members States. Designed primarily to support developing countries, the program enables States Parties to provide support on implementing the CWC to other States Parties that request it. IRSN's assistance will take the form of designing and delivering a training program based on courses and presentations of tools designed by IRSN or developed by the OPCW, particularly related to preparing and submitting declarations, and to inspections. The program will also include case studies and site visits.



04

## CONDUCTING RESEARCH AND PRODUCING THE KNOWLEDGE NECESSARY FOR EXPERT ASSESSMENT

IRSN's research activities, conducted to improve the knowledge supporting its expert assessments, aim to increase knowledge related to nuclear and radiological risks. The work done by IRSN's teams relies on national and international collaborations and on increasingly powerful experimental equipment.

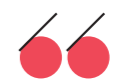
#### + SUCCESS OF THE FIRST TEST IN THE CABRI EXPERIMENTAL REACTOR FOR THE CIP PROGRAM

On April 16, 2018 IRSN and the CEA successfully conducted the first test in the CABRI research reactor, which has a water loop representative of pressurized water reactors (PWR). The experiment is an important step in IRSN's CABRI International Program (CIP), run under the auspices of the OECD/NEA to improve knowledge of nuclear fuel behavior in reactivity accidents.

The test was run to check that the pressurized water loop, for studying fuel behavior in a thermo-hydraulic configuration representative of a pressurized water reactor, is working correctly.

It also collected the first data for a study of the behavior of an irradiated mixed uranium-plutonium oxide (MOX) fuel subject to a sudden massive heat injection in a pressurized water loop. The signals registered by the many sensors during the test showed the failure of the test rod. They are now undergoing detailed analysis.

The success of this test paves the way for the program's continuation\* with different fuel and cladding types. It is the result of hard work by all partners in the program, which has united the scientific community around the use of large-scale experimental instruments.



The first test was successfully performed in the Cabri research reactor. It collected the first data for a study of fuel behavior in an accident situation.

\* (IRSN's partners in the CIP program are: CSN (Spain), SKI (Sweden), HSE (UK), US-NRC and EPRI (USA), HSK (Switzerland), VTT Energy (Finland), GRS (Germany), USV (Czech Republic), VUJE (Slovakia), KINS (Korea), EDF and CEA (France).



### FIRST TEST CAMPAIGN OF THE PRISME 3 PROJECT

The PRISME 3 program's first test campaign, conducted under the auspices of the OECD (NEA), ran from October 2017 to March 2018 at IRSN's DIVA facility, which since 2017 has had a renovated ventilation system for better measurement of extracted combustion products and exhaust flow rate. The campaign, entitled S3 for "smoke, stratification and spread", uses experiments to study the spread of smoke in different configurations representative of possible fire scenarios at nuclear facilities. The five tests carried out will be used to make further improvements to IRSN's SYLVIA and ISIS simulation tools used for studies to support expert assessments. The tests provided an opportunity to expose electrical equipment such as electric switch gears to a real fire, and provided data on malfunctions under representative conditions, particularly in terms of soot concentration and critical exposure temperature.

### PARTICIPATION IN POST-FUKUSHIMA-DAIICHI RESEARCH PROJECTS

IRSN has agreed to take part in three new projects run by the OECD's Nuclear Energy Agency (NEA) to prepare for the dismantling of the damaged Fukushima-Daiichi reactors. The first project concerns preparation for the recovery and analysis of fuel debris (PreADES); the second is a more detailed analysis of the state of the damaged reactors (ARC-F); the last will undertake the thermodynamic characterization of the fuel debris and fission products (TCOFF).

IRSN's involvement will enable it to contribute to the syntheses of knowledge acquired on the Fukushima-Daiichi accident, to provide

its expertise to the programs analyzing debris samples from the damaged reactors, and to improve its databases of thermodynamic data. The project will also provide an opportunity to better identify the limitations of tools and methods developed during IRSN's work on severe accidents by comparing them with the reality of an accident in which all phases have been analyzed.

**39.1 %**  
of budget allocated to research (excluding the Feurs project)

**262**  
publications listed in the JCR (Journal Citation Reports)

### STUDYING MODES OF GOVERNANCE OF NUCLEAR RISKS

The second conference of the AGORAS project (a French project to improve the governance of the organizations and networks involved in nuclear safety) was held in Montrouge on December 13 and 14, 2018 on the theme "Lessons learned? Studying learning devices and processes in relation to technological accidents". The purpose of the conference was to gain a better understanding of the way in which the entities responsible for nuclear safety understand and address the phenomena linked to the occurrence of accidents. It also aimed to encourage debate

around the methods used by researchers to analyze learning processes and the social and material conditions that make these processes possible.

IRSN is a participant in the AGORAS project, supported by the ANR as part of the Investment in the Future Program/Nuclear Safety and Radiation Protection Research, which aims to study changes in the modes of governance of nuclear risks after the Fukushima-Daiichi accident.

### In brief

#### Scientific conference

— IRSN organized the first Neutron Science Days jointly with the CEA on September 24 and 25, 2018 at Cadarache. Aimed at teams whose work is concerned with neutrons and their applications, these events provided an opportunity to share knowledge about the facility and the development of neutron sources, industrial and R&D applications, detectors and spectrometers, nuclear instrumentation, etc.

#### Seismic hazard

— The second workshop of the French seismological and geodetic network (RESIF), focusing on seismic hazard, was held in Montpellier from January 29 to 31. IRSN was heavily involved in organizing this meeting, which brought together engineers and researchers working on seismic hazard in France (IRSN, BRGM, EDF, CEA, etc.).

**28**  
theses defended

**442**  
scientific lectures at conferences

View of the Fukushima-Daiichi power plant and the temporary enclosure covering the damaged reactors.



### IMPROVING THE MANAGEMENT OF A SEVERE ACCIDENT AT A REACTOR

Launched in late 2017 and coordinated by IRSN, the international SAMHYCO-NET project aims to provide more detailed knowledge of the production of flammable gases in the later phases of a severe accident in order to improve the effectiveness of equipment, particularly catalytic recombiners, deployed to prevent explosion risks. This three-year research project run by NUGENIA will include complex tests of explosion and recombination of H<sup>2</sup>-CO mixtures at temperatures and pressures representative of those encountered in the later phases of a severe accident (post corium-concrete interaction).

The first safety assessment software intercomparison exercise was launched for an accident situation at a KONVOI pressurized water reactor to confirm the remaining uncertainties on which the R&D effort will focus.

IRSN's research teams have developed a nanoemulsion effective in the decontamination of wounds. The transfer of this technology to an industrial partner was completed in 2018.



#### ZOOM

#### SUCCESSFUL TECHNOLOGY TRANSFER WITH THE CEVIDRA LABORATORY

**IRSN has developed a nanoemulsion that is effective in the emergency treatment of radioactive contamination of the skin, which, with inhalation, is one of the main methods of contamination of nuclear industry workers. The work has led to the publication of nine papers and to the filing of a patent. The knowledge-sharing has continued, moving from a research partnership to an industrial partnership with the transfer of the technology under license to the Cavidra Laboratory. This new collaboration demonstrated the safety of the product and resulted in its release on the market in 2018.**

#### In brief

#### Research

— The research and teaching chair for the study of inter-organizational relations in high-risk industries, throughout the life of facilities (RESOH chair), has been extended for five years. The aim is to strengthen the formation and organization of this community of academic researchers, industrialists and institutions in order to increase discussion on the topic of nuclear safety.

#### Collaboration with the NRA

— In February 2018, the Japanese safety authority, NRA, expressed its interest in part in IRSN's "Glove Box Fire Research Collaboration Program", which aims to improve knowledge and modeling of the combustion process of solid panels inside a glove box. The program will run until 2023.



# 05

## ENHANCING INTERNATIONAL COOPERATION

In an international context where safety, security and radiation protection are a significant challenge, IRSN plays a driving role, particularly because of the diversity of its missions and its wealth of technical platforms. It receives numerous assistance requests. Its international cooperation enables it to enrich its expertise and knowledge and improve its research facilities. This engagement is therefore in the public interest. Multilaterally, the construction of a "common European area" for the TSOs remains a major priority, to benefit European harmonization. Bilaterally, IRSN aims to share its vision of the major nuclear safety and radiation protection challenges with its main partners.

### + CLOSE COOPERATION WITH THE IAEA

IRSN is heavily involved in promoting the action and role of the TSOs (technical safety organizations, which support the authorities) in improving nuclear safety, and played a key role in developing TECDOC 1835 (Technical and Scientific Support Organizations Providing Support to Regulatory Functions), the IAEA's first document specifically on the action and role of the TSOs, published in 2018.

IRSN also played an active part in the IAEA's organization of the fourth conference on "Challenges Faced by Technical and Scientific Support Organizations (TSOs) in Enhancing Nuclear Safety and Security", held in Brussels in October 2018. The conference was an opportunity to take stock and identify action to be taken by the IAEA to develop and deploy scientific and technical expertise in support of the governance of nuclear and radiological risks. The discussions at the conference gave the opportunity to promote TECDOC 1835 but also to prepare for further action by the IAEA:

- o to take better account of the TSOs' contributions in the IAEA's audit tools (e.g. IRRS);
- o to continue its support for the TSO initiative aimed at setting up a national TSO in countries developing a nuclear program, by providing independent expertise;
- o to recognize the importance of the TSOs' contributions to the independence and effectiveness of national regulatory systems and to openness to society and transparency;
- o to embark on the development of long-term strategic research plans to embed safety expertise.

IRSN was also heavily involved with the IAEA's center responsible for preparing for and responding to radiological emergencies, providing experts to the center to help with developing an approach to the assessment of accident situations.

#### In brief

#### Contribution to a Bel V expert assessment

— In late 2018, IRSN contributed to an expert assessment by Bel V, its Belgian counterpart, of the structural deterioration of a bunkered building at the Doel nuclear power plant containing level 2 safety equipment. The approach, which consisted of cross-checking and verifying the results of the expert assessments done by the two TSOs, reinforced Bel V's position and provided backing to the AFCN, Belgium's safety authority, in its authorization of the restart of the reactor in question.

## ZOOM

### A VERY ACTIVE CONTRIBUTION TO THE ETSO NETWORK

As one of the initiators of the ETSO network, IRSN plays an active role in its development and action to enhance nuclear safety and standardize practices across Europe. In 2018 ETSO consolidated its close relationship with the European Commission; an ETSO consortium of ten members of the network won a call for projects launched by the European Commission in late 2017. The project aims to assess the practical implementation of Articles 8a to 8c of Directive 2014/87/Euratom, which set an ambitious safety objective for nuclear facilities in the EU Member States and introduce assessment procedures for achieving this. In accordance with its Performance Target Agreement, IRSN makes an active contribution to this project; it is responsible for coordinating the assessment of the approaches and methods introduced nationally

in implementation of the Directive. ETSO also made a major contribution to organizing the IAEA TSO conference in Brussels in October 2018. Work on the technical guides related to safety assessments was also completed with the publication of a guide on the comparison of regulations for assessing vessels containing pressurized water in reactors and a guide to assessing the environmental qualification of equipment. A new expert group was set up within the Technical Board on Reactor Safety to look at how to take account of external naturally-occurring or man-made hazards. The first discussions were held in early 2018 at a workshop on how to take account of accidental aircraft crashes on nuclear facilities. These discussions were considered by IRSN in its reflections on the safety approach to new facilities.

## In brief

### Waste

— The SITEX\_Network association was set up in January 2018 to continue the scientific cooperation begun during the SITEX and SITEX II research projects supported by the European Commission. With IRSN holding the presidency, SITEX\_Network set itself the objective of developing international cooperation on radioactive waste management, in order to provide high-level expertise, independent of the industrial operators, to support the safety authorities and act as a link with civil society.

### NEA

— On September 25, the Director-General of the OECD's Nuclear Energy Agency (NEA) visited IRSN's main experimental platforms on the Cadarache site. The visit took place in the context of longstanding and close cooperation between IRSN and the NEA.

### ENHANCED COOPERATION WITH THE USA ON NUCLEAR SAFETY AND SECURITY

At the annual Regulatory Information Conference (RIC) organized in March by the American nuclear safety authority, the US NRC, IRSN strengthened its cooperation with its main transatlantic partners.

A cooperation agreement on flood risk assessment at nuclear facilities and various collaborative projects were begun on experiments related to concrete degradation and spent fuel pool uncovering.

With the US Department of Energy (DoE), which operates a research reactor known as TREAT with functions that complement those of CABRI, different tests will be carried out on the behavior of innovative nuclear fuels. Cooperation between the two organizations on criticality risks will also continue.

Finally, discussions with the National Nuclear Security Administration (NNSA) moved forward, especially on the problems of security and safeguards, and preparing for radiological emergencies.

### EXTENSION OF THE PARTNERSHIP WITH CHINA

As part of a series of contracts under the European Commission's Instrument for Nuclear Safety Cooperation (INSC), IRSN assisted the Chinese TSO, NSC, and China's safety authority, the NNSA, in the fields of design-basis accidents and severe accidents at power reactors. Through these collaborations, IRSN promotes its experience and its computer codes designed specifically for steam explosions (MC3D) and severe accidents (ASTEC). In October 2018, at a three-day workshop organized in Beijing by IRSN and the Chinese TSO, NSC, Chinese users and guest organizations (NSC, CNNC/CNPE, CGN/CNPRI, SNPTC/SPIC, universities) were able to share their experience of using the ASTEC code and to submit their development ideas to IRSN's experts who, in turn, presented the code's latest features. The desire of all the participants to hold similar discussions on a regular basis in future was formally recorded.

IRSN is also a partner of the Chinese nuclear engineering firm CNPE, which awarded it a contract in 2018 for services on 17 nuclear safety-related themes.

In the area of radiation protection, several areas of cooperation were identified with NSC and the Chinese radiation protection institute (CIRP).

### ENHANCED COOPERATION WITH JAPAN

2018 was marked by an increase in discussions on radiation protection and study of the health effects of ionizing radiation between IRSN and its Japanese counterparts: Nagasaki University, the Radiation Effects Research Foundation, and the National Institutes for Quantum and Radiological Science and Technology. In particular, these discussions resulted in the signature of an agreement with Nagasaki University in October 2018.

## In brief

### Research

— IRSN took part in a PIRT (Phenomena Identification Ranking Table) exercise organized by the OECD, the purpose of which was to define research programs to be launched into loss of coolant accidents affecting spent fuel pools. The task involved 22 organizations from 15 countries. It identified the most important phenomena, selected those for which there was insufficient knowledge and recommended priority actions in terms of experimental programs, development of models and development of simulation tools.

### COOPERATION WITH THE RUSSIAN TSO

In 2018 IRSN renewed its cooperation agreement with the Russian TSO, SEC NRS, for 10 years in the fields of nuclear safety and security. SEC NRS has been an associate member of ETSO since 2012.

The areas of cooperation include hydrogen safety and the methodology for assessing risks associated with the chemical processes used at fuel cycle facilities. New areas of cooperation have been defined concerning waste management and dismantling strategies, as well as the validation and quantification of uncertainties in the codes used for safety studies.

### INTENSIFICATION OF COOPERATION WITH SINGAPORE

In the context of the cooperation agreement (memorandum of understanding) on nuclear safety, cooperation between IRSN and the National University of Singapore (NUS) was strengthened with the creation at the NUS of a nuclear safety research unit (SNRSI). Several Singaporean researchers came to IRSN and ENSTTI (European Nuclear Safety Training and Tutoring Institute) for training on the environment (radiochemistry), the effects of radiation (radiobiology) and safety analysis, especially in accidents. Regional training courses in nuclear safety, organized jointly by SNRSI, IRSN and ENSTTI, were also run on a regular basis at NUS.



General view of the VIKTORIA loop used to conduct experiments under conditions representative of those likely to be encountered in different types of nuclear reactor during a loss-of-coolant accident.

## ZOOM

### THE VIKTORIA LOOP, AN EXEMPLARY TOOL FOR COOPERATION IN NUCLEAR SAFETY

Seventeen years after IRSN and the Slovakian engineering firm Vúez launched a nuclear safety research program, a delegation from IRSN visited Levice, Slovakia, in July 2018 to take stock of the achievements and consider the next phases of the program. The program has contributed not only to improving the filter components used in many reactors, especially outside the European Union, but also to identifying certain physical or chemical phenomena that can affect reactor safety. Beyond the Franco-Slovakian partnership, this enhanced understanding has already been shared with the international community, particularly through the Committee on the Safety of Nuclear Installations of the OECD's Nuclear Energy Agency.

The program was based in particular on tests conducted at the VIKTORIA facility, including a test carried out in 2018 related to a severe accident scenario. Since 2012, VIKTORIA has contributed most notably to qualifying the filters used in the containment sumps of various types of nuclear reactor. The VIKTORIA facility is exemplary in more than one respect: a genuine joint effort with costs shared between Vúez and IRSN, its design, construction and operation could be used as a model for future cooperation projects between IRSN and its international partners, to equip itself with vital tools for tomorrow's research into nuclear safety and radiation protection, in a context of research resource optimization and sharing.

# 205

bilateral cooperation agreements in force with research and assessment organizations

# 47

international projects in progress under the aegis of OECD-NEA, the European Commission or ANR

# 48

countries involved in these agreements



06

## ACTING TO PROTECT THE ENVIRONMENT

Alongside its research to discover and understand what happens to radioactive substances in the environment, IRSN also carries out permanent environmental radiation monitoring, which is vital to detect abnormalities. Because of its vast expertise in the radiation protection of humans and ecosystems, IRSN is also called upon by the authorities to help with individual planned or emergency tasks in potentially contaminated public and private places or former industrial sites.

### + WORK ON CONTAMINATED SITES

Because of its technical expertise and operational radiation protection skills, IRSN carries out planned or emergency tasks at the authorities' request, to eliminate doubt when exposure to radiation is suspected in public or private places. During this work, IRSN characterizes the radioactive source or contaminated site by taking in situ measurements, where necessary secures any radioactive objects pending their removal by Andra, assesses and explains the associated risks, and advises stakeholders. In 2018 IRSN was called to the apartment in Orléans (Loiret) of a deceased collector who owned various minerals, some of which were highly radioactive.

During the summer, it also responded urgently to make the watchmaking workshop at Edgar Faure high school in Morteau (Doubs) safe before the start of the academic year. The workshop contained old watches and clocks with hands covered in radioactive paint. Multiple interfaces (authorities, fire service, members of the public, etc.) are involved in these operations, which are conducted in a variety of contexts with widely varying radiological risks.

IRSN also supports the public authorities with managing construction on sites contaminated by historic industrial activities or the use of naturally-occurring radioactive materials. This support may consist of giving opinions on the monitoring protocols used or checking compliance with site cleanup requirements.



IRSN carries out planned or emergency tasks at the authorities' request, to eliminate doubt when exposure to radiation is suspected in public or private places.

In 2018 IRSN took measurements following the cleanup of two sites in Piriac-sur-Mer and Guérande (Loire-Atlantique) where uranium-bearing tailings had been found. IRSN also issued an opinion on the monitoring methods planned for the emptying of a body of water downstream of the uranium mining site at Saint-Pierre (Cantal).

### + REPORT ON ASSESSING THE TOXICITY OF RADIOACTIVE MATERIALS AND WASTE

#### In brief

#### Report on monitoring in French Polynesia

— IRSN published a report on radiation monitoring in French Polynesia carried out by its laboratory in Tahiti, and presented it to the local authorities. The radioactivity levels measured remain very low, as in previous years. They confirm the absence of any detectable impact in Polynesian waters from contamination of the marine environment caused by the accident at the Fukushima facility in Japan.

IRSN submitted a report to the Directorate-General for Energy and Climate (DGE) and the ASN on the toxicity of radioactive materials and waste, in response to a request in France's National Radioactive Materials and Waste Management Plan. The report describes the methodology and criteria proposed by IRSN to assess the hazard level associated with different categories of radioactive materials or waste. The approach used by IRSN is based on a set of indicators that cover the chemical and radiological components of the toxicity, that take account of their effects on humans and the environment, and that also cover the main exposure pathways and a variety of contexts.

For each situation, the report describes in detail the assumptions and parameters proposed by IRSN for calculating the exposure associated with the radioactive materials or chemical elements present in a "package". These choices are designed in particular to ensure assumptions are realistic while making the scenarios generic and standardized in nature.

The report also gives an example of the application of the method to several types of waste package and makes proposals with a view to wider deployment so that ultimately information is held about the toxicity of each of the waste families defined in Andra's national inventory. With this prospect in mind, it identifies points that could be explored further.

**A NEW TYPE OF INTERCOMPARISON**

To validate the reliability of the equipment used by laboratories measuring radioactivity in the environment, the ASN gives IRSN responsibility for organizing inter-laboratory tests (EIL). Among the four to six tests it organizes each year, IRSN introduced a new type of exercise this year to test the detectors of remote monitoring networks near nuclear facilities. This test, which brought together on the Le Vésinet site all the stakeholders involved in this type of monitoring, with their own equipment, revealed the quality of the systems installed in France.

**TOURNEMIRE:  
30 YEARS OF RESEARCH**

The underground laboratory at Tournemire (Aveyron) is one of four research laboratories in Europe in a clay medium. Built in a former railway tunnel dating from the 19<sup>th</sup> century, it has housed experiments since 1989 and was acquired by IRSN in 1992. Its purpose is to acquire methodological and phenomenological knowledge about clay in order to identify, understand and prevent the risks associated with the deep geological disposal of radioactive waste. The research done there by IRSN, entirely independently of Andra, contributes to the quality of IRSN's expert assessments carried out at the public authorities' request for the safety assessment of Andra's Cigeo disposal facility project in Meuse/Haute Marne.

This year, as part of its public information mission, IRSN's laboratory opened to the public, giving a guided tour on the topic of "The mysteries of water in clay". During this open day, visitors could take part in educational events and experiments and could talk to experts and researchers.

**CONTRIBUTION TO THE EUROPEAN METRORADON PROJECT**

Working in support of the public authorities and local stakeholders to prevent the risks associated with radon in homes, IRSN also contributes to the development of knowledge on the subject. On this basis IRSN is involved in the European MetroRadon research project launched by 15 partners as part of the European Metrology Programme for Innovation and Research (EMPIR). The project aims to improve the measurement of low radon concentrations in the air and to study the impact of thoron (a radon isotope) on radon measurements, as well as solutions for overcoming it.

MetroRadon has two further objectives: to compare measurement methods and to study approaches to identifying priority areas for managing the risk posed by radon in buildings. In addition to developing knowledge, the work is contributing to the standardization and improvement of Member States' practices, in line with the new requirements of the European directive on health protection against the risk associated with radon.

**479**  
monitors including 425 fixed Teleray stations form the national remote monitoring network

**139**  
ambient dose rate measurement points

**505**  
sampling points for radioactivity monitoring throughout France

**4,465**  
environmental samples taken for radiological measurements

An IRSN expert presents research in progress in the West-2008 drift of the Tournemire tunnel.



**PLAYING AN ACTIVE ROLE IN PUBLIC HEALTH**

As part of its radiation protection missions, IRSN divides its action to protect the public, workers and patients into three areas: monitoring, assessment and research. It thus plays a role in public health through its work on radiological risks, to which it takes a multidisciplinary approach and which is the subject of national, European and international cooperation.

**REPORT ON SCANNERS AND RADIATION PROTECTION IN MEDICAL IMAGING**

At the request of the Directorate-General for Health and the Directorate for Social Security, IRSN studied the state of France's fleet of medical scanners, its evolution and the effect of scanner age on the doses received by patients. To do this, IRSN used two databases that it manages on a regulatory basis: SIGIS, the system for information and management of sources of ionizing radiation, and the NRD database for managing diagnostic reference levels. The results of its analysis were accompanied by recommendations designed to improve the radiation protection of patients during medical imaging. The study shows that, in 2017, the average age of the 1,175 scanners in service in France was 3.6 years and their average operating life was 6.1 years.

It revealed a reduction of around 25% in the doses delivered by scanners installed in 2015 compared to those dating from before 2010, and that the vast majority of scanners that are more than 10 years old are in public establishments. IRSN therefore recommended, as a priority, the replacement of any scanners that are more than 10 years old, or more than 7 years old in pediatrics or, failing that, the introduction of an incentive for upgrading scanners when the upgrades proposed have a beneficial effect on their performance. Discussions with health professionals and the analysis carried out for this report identified an increase in the number of scans and in practices with an impact on the

radiation protection of patients, which could be caused by the current reimbursement system. IRSN recommended the introduction of a more stringent justification system for scans through easier access to imaging techniques that do not involve radiation, continuing training of requesting physicians, better patient information, and changes to the reimbursement system. The introduction of medical record sharing and regulatory obligations related to quality assurance, and the regular involvement of physicians in imaging services, should also improve the radiation protection of patients (dose and image quality).



PARISII brings together the necessary infrastructures to study the biological effects of an internal contamination by radionuclides.

### PARISII: A RESEARCH PLATFORM ON THE INCORPORATION OF RADIOACTIVE SUBSTANCES

IRSN carried out its first experiments using the PARISII platform, the only one of its kind in Europe, which it built to study the effect of the chronic incorporation through ingestion and inhalation of different radioactive substances by rodents (uranium, cesium, strontium). These experiments aim to gain a better understanding of the biological effects of this internal contamination and the body's adaptive response.

PARISII consists of two technical platforms for in vivo and in vitro experiments. The PARISII platform, which is open to national and international scientific collaborations, is designed to host teams of researchers. Collaborations will be supported by IRSN's multidisciplinary research teams, which include toxicologists, radiobiologists, chemists, veterinarians, and physiology and animal experiment technicians.

### EXTENSION OF THE PRIODAC PROJECT

Launched in 2014 for 5 years, the PRIODAC project (repeated stable iodine prophylaxis in accident situations) will be extended for 3 years. The PRIODAC project, coordinated by IRSN, uses experiments to study whether stable iodine tablets should be taken repeatedly in the event of repeated or prolonged exposure to radioactive iodine during a nuclear accident. The aim is to identify the best dosage and administration rates and evaluate potential side effects for different categories of the population. Financially supported by the ANR as part of its Investment in the Future Program/Nuclear Safety and Radiation Protection Research, the project involves IRSN, the CEA, Pharmacie Centrale des Armées, the University of Aix-Marseille and the University of Nice.

### In brief

#### Dosimetric assessment

— In response to a request by Le Mans University Hospital, IRSN carried out a dosimetric assessment of the doses received by a pregnant patient and her fetus during a scan of the patient's lumbar spine when larger than normal doses were accidentally delivered. IRSN provided technical support as part of action by the health authorities in response to this event: a reactive inspection at the hospital, a rapid alert message to establishments in France, a hearing with the manufacturer of the scanners in question, an "imaging experience feedback" working group.

### ZOOM

#### NEW PORTAL FOR IRSN'S RADIATION PROTECTION TRAINING

In accordance with its decree of March 10, 2016, IRSN must "contribute to the radiation protection training of health professionals and people subject to occupational exposure". To share its knowledge and expertise, ensure the greatest number benefit, and thereby contribute to better prevention and protection against the risks related to ionizing radiation, IRSN offers numerous training courses presented in a catalog managed by ENSTTI (European Nuclear Safety Training and Tutoring Institute). It is aimed at anyone who uses ionizing radiation at work: radiologists, radiographers, occupational physicians, people working in industry, engineers in nuclear safety, radiation protection or the environment, etc. IRSN's training offer can be accessed at [formation.irsn.fr](http://formation.irsn.fr), where professionals can sign up, find course materials and communicate direct with the trainers.

# 556

whole-body countings for the individual monitoring of workers

including **341** with mobile facilities

### ZOOM

#### HEIR 2018 CONFERENCE

As lead bodies in radiotoxicology and radiobiology research, IRSN and the CEA jointly organized the twelfth international conference on the Health Effects of Incorporated Radionuclides, at Fontenay-aux-Roses (Hauts-de-Seine). For four days, 140 participants discussed the latest advances in the various fields related to the study of incorporated radionuclides (biokinetics, radionuclide chemistry, dosimetry of internal contamination, radiotoxicology, radiobiology, etc.) and the applications that use radionuclides in nuclear medicine (medical imaging, therapy).

### In brief

#### Treatment of radiation victims

— After four years' research, the ANR-GIPSIS project (blood stem cell generation from induced pluripotent stem cells (iPSCs)) has reached a crucial stage for the treatment of radiation victims. Launched in cooperation with Saint-Antoine hospital and coordinated by IRSN, the project has succeeded in obtaining bone marrow transplants from iPSCs from a human skin biopsy. The efficacy of these transplants has been demonstrated in mice whose bone marrow was totally destroyed by irradiation.

#### EURADOS

— In July 2018, IRSN published a summary of the results of an intercomparison exercise that it ran in 2016 for the EURADOS network, on assessing lifetime doses received by nuclear workers exposed to uranium.

### FIRST RESULTS OF THE ÉPICE STUDY LAUNCHED IN THE WAKE OF THE CHERNOBYL ACCIDENT

The ÉPICE program (evaluation of diseases potentially induced by chronic cesium contamination) aims to provide answers to a scientific but also societal question: what have the health consequences of the Chernobyl nuclear accident been for children exposed to its fallout? It aims to collect scientific information about non-cancerous effects potentially caused by chronic exposure to low doses of ionizing radiation, by looking into the existence of a relationship between that exposure and cardiovascular disease risk. The first results were published in the British Medical Journal Open.

Following a pilot phase, the first part of the ÉPICE study involved systematic screening of more than 18,000 children aged between 2 and 18 years for cardiac arrhythmias. Half of the children live in areas contaminated by cesium-137 and half in non-contaminated areas in the Bryansk region (Russia), northeast of the Chernobyl power plant.

All children had three medical examinations: an ECG, a cardiac ultrasound and a cesium-137 whole-body activity measurement. Some were also given 24-hour Holter monitoring and blood tests.

The examinations did not identify a relationship between cardiac arrhythmias and the cesium-137 deposits in the Bryansk region. 1,172 children living in the contaminated areas and 1,354 children living in the non-contaminated areas were diagnosed with a cardiac arrhythmia, indicating that this disease is less prevalent in contaminated areas (13.3%) than in non-contaminated areas (15.2%).

The second part of the ÉPICE study should look at the incidence of ionizing radiation on the development of lens opacity.



IRSN's SPICE program aims to gather scientific information on non-cancer effects possibly induced by chronic exposure to low doses of ionizing radiation, looking into the existence of a relationship between the risk of cardiovascular disease and this exposure.

## OCCUPATIONAL EXPOSURE REPORT: NEW METHODOLOGY

Every year IRSN publishes a report on occupational exposure to ionizing radiation. For the first time ever, the 2018 report was based solely on individual personnel monitoring data recorded in the SISERI system rather than aggregate data supplied by the dosimetry organizations. This approach reduces errors caused by the distribution of personnel between different occupational activities and means better targeting of workers with the highest exposure levels.

The survey of the 384,198 workers monitored in France as part of their occupational activity involving ionizing radiation shows that exposure levels are stable. Average individual external exposure is stable overall. The study shows that contractors account for a third of the nuclear workforce but receive more than two thirds of the total collective dose recorded in this sector. The average individual dose for contractors (1.68 mSv) is higher than that of nuclear industry workers (1.28 mSv). The annual regulatory effective dose limit (20 mSv) was exceeded in the case of two workers, one in the medical and veterinary sector and the other in a non-nuclear industry. Internal exposure was limited. In 2017, three workers received a committed dose of more than 1 mSv, the highest being 4 mSv.

### THE REPORT IN FIGURES

#### STEADY INCREASE IN THE NUMBER OF WORKERS MONITORED

**384,198**

workers monitored in 2017  
(up 1.6% on 2016)



**0.72**

millisievert (mSv) on average in individual external exposure for the exposed workforce (excluding workers exposed to enhanced naturally-occurring radioactivity)



**2**

workers exceeded the regulatory limit of 20 mSv

#### EXPOSURE BY SECTOR



Average individual dose by field (mSv)

#### SHORT-TERM REDUCTION IN COLLECTIVE DOSE

Reduction of

**20 %**

in the collective dose (53.5 man-Sv compared to 66.7 man-Sv in 2016) mainly due to a reduction in activity in the nuclear field.



**08**

## PREPARING FOR EMERGENCIES AND POST- ACCIDENT MANAGEMENT

In case of an incident or accident, IRSN is responsible for putting forward proposals to the safety authorities on technical, health and medical measures to protect the public and the environment in the area concerned and for supporting the public authorities. As a member of the national response system for nuclear and radiological emergencies, its teams take part in national and international exercises and IRSN contributes to updates to France's policy for post-accident management. As part of this, it studies the experience feedback from the post-accident management of the Fukushima-Daiichi accident.

### DETECTION IN OCTOBER 2017 OF RUTHENIUM-106 IN EUROPE: RESULTS OF IRSN'S INVESTIGATIONS

IRSN published a summary of the investigations it carried out following the detection of ruthenium-106 in the atmosphere over France and Europe in October 2017. Its report was submitted on January 31, 2018 at the first meeting of the international committee of experts set up by the Russian authorities to find the source of the ruthenium-106.

Ruthenium-106 was detected by a number of European atmospheric radioactivity monitoring networks, including IRSN's, at levels of around a few millibecquerels per cubic meter of air, which have no health or environmental impact in France. Using the available data, IRSN performed simulations to locate the source of the releases and evaluate the quantity of ruthenium released and the release period and duration. Its knowledge of fuel cycle processes enabled it to determine the type of facility that might have been the source of a ruthenium-106 release.

Its report concludes that the hypothesis that best explains the recorded activities is of a release of a large amount of ruthenium between Volga and Ural in late September 2017. Given the ratio of ruthenium-103 to ruthenium-106 detected in some samples, the release is likely to be linked to an industrial activity using spent fuel unloaded from a nuclear reactor approximately two years earlier. IRSN's conclusions are in agreement with those of the committee as regards the size of the release, the impossibility of the origin being a medical source or a satellite, and the hypothesis of an incident during the reprocessing of irradiated spent fuel cooled for around two years. However, the experts did not reach a consensus as to the precise location of the release.

### INCIDENT AT NOGENT NUCLEAR POWER PLANT: IRSN ACTIVATES ITS EMERGENCY RESPONSE

IRSN activated its Emergency Response Center overnight on July 17 to 18, 2018 due to an incident at the nuclear power plant in Nogent-sur-Seine (Aube). In the evening of July 17, a fire broke out in a transformer supplying power to the two reactors on the nuclear site. The loss of power mainly affected reactor 2, which was shut down at the time. All the fuel from this reactor had been unloaded into the spent fuel pool and maintenance was under way, limiting the number of available electricity sources. However, cooling of the pool was maintained throughout the incident. The power supply in question was restored and IRSN's Emergency Response Center was deactivated in the morning of July 18.

## NEW CONTRIBUTIONS TO CODIRPA'S WORK

Since the publication in 2012 of the national policy for post-accident management, numerous lessons have been learned from the reflection process begun following the Fukushima-Daiichi disaster in 2011. These lessons have led to significant improvements in knowledge of how to manage the consequences of an accident situation and to the development of modeling tools and equipment for measuring environmental contamination.

The regulatory context has also changed significantly with the publication in 2013 of France's national emergency response plan for major nuclear or radiological accidents and the transposition into French law in 2018 of Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation.

In this context, IRSN identified issues to be discussed during CODIRPA's work on updating the post-accident management policy. These include, for example, achieving greater consistency between measures taken during an emergency and measures taken in the post-accident phase, improving the account taken of the results of environmental contamination measurements when defining post-accident zoning, and taking a time-based approach to zoning so that changes can be anticipated more effectively.

IRSN also contributed to the working group on the involvement of local stakeholders in preparing for post-accident management, by drafting answers to questions asked by health professionals and preparing a guide designed for the population. IRSN also designated a number of experts (emergency response, dispersion, radioecology, economy) to participate in a new working group on post-accident problems associated with the marine environment.

### In brief

#### WHO

— In 2018 IRSN was designated for the second time as a World Health Organization collaborating center to provide support on radiological risks. The support provided by IRSN concerns preparation for radiological emergencies, internal and external dosimetry, medical radiation protection and the health impact of radon.

#### REPORT ON SURVEYS CONDUCTED AT FUKUSHIMA FOR THE SHINRAI PROJECT

IRSN wrote a report presenting the results of three case studies carried out in the Fukushima prefecture for the SHINRAI (which means "trust" in Japanese) project. Coordinated by IRSN with the involvement of Sciences Po Paris and Tokyo Tech University, the project is studying the social and political consequences of the Fukushima-Daiichi accident. In particular it is interested in changes in citizens' trust in institutions following a nuclear accident.

The report, based on a large survey, analyzes the issues of returning or not returning to evacuated villages, categorizing residents on the basis of their decision. It discusses the role of government officials, physicians and radiation protection experts, looking particularly at the dilemmas facing the mayors of the evacuated towns. The report concludes with possible ideas for updating post-accident policies

### ZOOM

#### EURATOM DIRECTIVE: SUPPORT FOR TRANSPOSITION REGARDING THE ASPECTS RELATED TO EMERGENCIES

IRSN was heavily involved in the finalization of the decrees transposing European Directive 2013/59/Euratom into French law, in support of the public authorities. This Directive updates the "basic safety standards for radiation protection", designed to protect the public, patients and workers from ionizing radiation. These new texts modify the French radiation protection system established particularly by provisions of the Public Health Code and the Labor Code on protection from ionizing radiation. IRSN made a particular contribution to the drafting of the provisions on protecting the public in radiological emergencies and long-term post-accident exposure situations.

1

action taken by the emergency response center, CNPE Nogent

8

national nuclear emergency exercises excluding defense-related activities

1

national nuclear emergency exercise involving defense-related facilities

#### PREPARATION FOR NRBC EMERGENCY RESPONSE

The government's response plan for an NRBC (nuclear, radiological, biological, chemical) emergency gives IRSN a supporting role towards the public authorities responsible for handling the situation. To provide the right operational support, IRSN has identified initial actions to be taken in all situations covered by the plan. The aim is to develop and strengthen its expert assessment capabilities and to improve its response skills on the ground and its technical measurement equipment. IRSN's teams also took part in several local exercises on this theme during 2018.

#### DISCUSSIONS ON FASTNET PROJECT TOOLS

As coordinator of the European FASTNET (Fast Nuclear Emergency Tools) project, IRSN organized a training course for 38 participants from 22 countries, held at Fontenay-aux-Roses on May 28 to 30, 2018, on the tools and methods developed as part of the project to predict atmospheric releases in an accident affecting a nuclear power reactor in Europe (PWR, BWR, VVER and CANDU technologies) or a spent fuel pool. To date, around a hundred standard releases calculated using different reference codes (ASTEC, MAAP, MELCOR) are included in the database of accident scenarios used for the project.

The project partners also had an opportunity to use the FASTNET tools during two exercises, one solely on calculating releases, conducted on their own premises, and the other looking more widely at managing protection of the population, held in Vienna with assistance from the Austrian BOKU university.

4

ionizing radiation dose assessments by biological dosimetry

13

meetings involving IRSN as part of CODIRPA's work on post-accident management

#### IRSN WORKS AS A PARTNER OF THE US DEPARTMENT OF ENERGY ON CRITICALITY

In the context of its cooperation with the US Department of Energy (DoE) on safety in the area of criticality risks, IRSN took part in May 2018 in a dosimetry intercomparison exercise organized at the FLAT-TOP experimental reactor at the Nevada National Security Site. The aim of its involvement was to maintain and strengthen IRSN's operational ability to assess correctly and quickly the doses of radiation received by victims of a criticality accident so that they can be given the best possible medical treatment.

Apart from IRSN, around ten American laboratories also took part in the exercise, with each one having to use its own criticality accident dosimeters to assess the neutron and gamma radiation doses received by dummies placed around the reactor.

#### IRSN MODERNIZES ITS FACILITIES FOR ANALYZING ENVIRONMENTAL SAMPLES

At its Le Vésinet site specializing in the characterization of human and environmental exposure, IRSN designed an extension to its laboratories used for analyzing environmental samples, the laboratory for the treatment and analysis of environmental samples in a post-accident situation (LATAc). In a post-accident context, this additional infrastructure will make it possible to carry out expert assessments and measurements to check the contamination of foodstuffs. The construction phase of the project will run from early 2019 to late 2020.

### In brief

#### Emergency response exercises

— In 2018 IRSN took part in 9 national emergency response exercises and 2 international exercises. To complete the training of the emergency response center team members, IRSN has also been involved in around ten local exercises run by operators (e.g. an exercise at Toulon naval base). In parallel, teams using technical equipment on the ground received training during three internal exercises and five exercises run jointly with their mission partners.



Team coordination meetings are regularly held during emergency response exercises

#### New emergency response center

— After a year's preparation, IRSN's new emergency response center went into service in fall 2018. The center is larger and more modern than the previous one and can accommodate all the emergency response units, including the new units responsible for international relations and health assessment set up in response to feedback from the Fukushima accident, which are necessary for fulfillment of the tasks assigned to IRSN in the national emergency response plan for major nuclear or radiological accidents.



IRSN's new emergency response center can accommodate all the response teams and takes account of experience feedback from the Fukushima-Daiichi accident.



09

## INFORMING SOCIETY OF THE RISKS

Since its creation, IRSN's information and communications policy has taken account of legislative requirements regarding transparency on risks and environmental issues, society's new expectations, and new technologies. It uses innovative educational methods, participative science and partnerships with other organizations to reach an ever wider audience.

### VALENCE-D'AGEN: AWARENESS OF RADIOACTIVITY AMONG THE PUBLIC AND SCHOOL PUPILS

IRSN took the opportunity provided by an emergency response exercise in March 2018 at the Golfech nuclear power plant (Tarn-et-Garonne) to share with the local community its knowledge about radioactivity. The joint ASN/IRSN traveling exhibition "Radioactivity: Hundreds of Questions" was installed in Valence d'Agen town hall during a public information meeting about the emergency response exercise. This educational resource is available to mayors, teachers, local information commissions, associations, company managers and health professionals, and has already reached a large number of citizens and school children across France. In parallel, IRSN also presented its OpenRadiation collaborative science initiative, launched in 2017 with three partners, at Jean Baylet high school in Valence d'Agen, along with a workshop on measuring and sharing in real time the results of ambient radioactivity measurements.

### ELEVENTH INTERNATIONAL RADIATION PROTECTION WORKSHOP IN SCHOOLS

The radiation protection workshops in schools aim to help promote scientific and technical culture in schools and to initiate a socially responsible approach among pupils through the appropriation of scientific and social facts related to ionizing radiation. The annual event enables pupils to present work done during the year with their teachers and with support from radiation protection experts. In 2018, more than 140 high school pupils and their teachers from Germany, Belarus, France, Japan (Fukushima high school), Moldova and Ukraine met at the University of Burgundy in Dijon to present their work on radioactivity. During the three-day workshop run by IRSN, ASN, INSTN, CEPN and SFRP, they worked on topics as varied as natural and artificial radioactivity, the use of ionizing radiation in the medical field, the effects of ionizing radiation on living organisms, and the consequences of a nuclear accident. The pupils' presentations and the talks and round table discussions run by the experts provided an opportunity for sharing knowledge, comparing experiences, and dialog.

**3,810,534**  
pages viewed on the IRSN website

**157,557**  
pages viewed in the "Research" section (formerly the "scientific site") of the IRSN website

**334**  
notices and reports published on the IRSN website

### INTERNATIONAL: SHARING PRACTICES AND EXPERTISE

From October 1 to 5, 2018, IAEA held its first international symposium on communication during nuclear or radiological emergencies. The symposium was attended by 400 people from 74 Member States and 13 international organizations. The audience consisted of communication professionals, members of government departments, and specialists in emergency response. Young people were also well represented, and a session was held specifically for them with a special "innovation" prize.

The symposium included some new digital features: dedicated apps (600 downloads), live web streaming, live questions with the floor.

IRSN made an active contribution to the event with its participation in the program committee, the review of more than 400 contributions, and presentations. At the end of the symposium, the program committee submitted its recommendations to the IAEA.

Another major event, the fifth European IRPA Congress (International Radiation Protection Association) took place in The Hague (Netherlands) from June 4 to 8, 2018. 700 radiation protection researchers and experts discussed the state of the art and the various advances made in the field.

IRSN gave around ten oral and poster presentations.

Its dosimetry services and the OpenRadiation project run by IRSN and its partners were presented on IRSN's stand.

### OPERATION CHERBOURG 2018: PUPILS ACTIVE IN ENVIRONMENTAL MONITORING

IRSN invited pupils from three schools in the Manche department Thomas Hélye high school in Cherbourg, Métiers Nature high school in Coutances, and the Saint-Lô Institute in Agneau to take part in environmental monitoring in their area. Working with their teachers, it helped them to develop a scientific approach to measuring tritium in rainwater.

115

students from French and foreign schools took part in the radiation protection workshops in schools initiative

6

publications produced by IRSN

### ZOOM

#### THE TOP 15 MOST VIEWED ITEMS ON IRSN'S WEBSITE IN 2018 ENVIRONMENT FACTFILE ON "RADON"

- "Understanding the basics of radioactivity" Nuclear & Society factfile
- "The Chernobyl accident (Ukraine 1986)" Safety factfile
- "Radioactivity and its effects on humans" Health factfile
- "Seismic risk and nuclear facilities" Safety factfile
- "The Fukushima Daiichi accident (Japan 2011)" Safety factfile
- "The Operation of French Nuclear Reactors" Safety factfile
- "Radiotherapy" Health factfile
- "Radiation protection for workers" Health factfile
- "Radiation protection officers" Health factfile
- "Origins of radioactivity: Natural and artificial radiation in France" Environment factfile
- "Exposure of the French population to radioactivity" Health factfile
- "Dismantling of basic nuclear installations" Safety factfile
- "Medical imaging" Health factfile
- "Three Mile Island (United States 1979)" Safety factfile



### EDUCATIONAL INITIATIVES AND PARTICIPATIVE SCIENCE

IRSN was once again heavily involved in the 2018 Science Fair on "received ideas". At the Cité des Sciences et de l'Industrie (Paris), IRSN was a partner on the "Cabaret de la Science" television program, where it talked about the risks related to radioactivity, radon and cosmic radiation, and the use of radiation in industry. Using the medium of science theater, one of the new features of the 27th Science Fair, IRSN looked back at the history of radium from the viewpoint of radiation protection. At Aix-en-Provence in the Bouches-du-Rhône department, IRSN offered experiments on the fire whirl, and explanations for air movements during a fire and on its research on fuel cladding. At Arles, IRSN opened the SORA station

to the public, which monitors water quality in the Rhône and detects any radioactive elements. At Vinon-sur-Verdon (Var), it ran an OpenRadiation workshop. Lastly, the traveling exhibition "Radioactivity: Hundreds of Questions" visited Dézert (Manche).

Outside this flagship event, IRSN organized a seminar entitled "Radon and the land" in Montbéliard (Doubs). Discussions with local communities, elected representatives, and the construction industry led to improvements in the management of radon risk and indoor air quality. The event was an opportunity to present outreach and training actions and radon measurement campaigns conducted in France.



10

## MODERNIZING AND IMPROVING EFFICIENCY

IRSN's actions are aimed at harnessing human potential, ensuring that the organization is run efficiently and responsibly, and continuing its modernization in the context of responsible management. Its actions are also a reflection of government modernization policies.

### PREPARING IRSN FOR 2030

In 2018 IRSN continued working on its IRSN 2030 strategic approach to prepare itself to meet the challenges of coming decades. Four goals were identified and associated strategic orientations were developed in a document entitled "Strategic Goals for 2030". The continuation of this work in 2018 included a collective reflection process begun at the start of the year through the organization of 14 workshops attended by 174 employees. More than 300 suggestions were made, in the form of ambitions, actions and conditions of success, to enable IRSN to effectively anticipate changes in its environment. Drawing inspiration from some of these, the steering committee for this initiative chose to begin initial experimentation on themes related to the use of artificial intelligence and augmented expertise, the emergence of Open Data, the development of openness to society in research, and taking more account of IRSN's social responsibility. A call for projects, with

particular priority given to transversal and multidisciplinary projects, was launched in the second half of 2018 on the first three topics. Six projects were chosen, lasting nine months to a year. They relate to the organization of transversal workshop on the data sciences at IRSN, and the development of expert systems, partly to study the effects of ventilation on fire source term and partly to make use of data from the reactor coolant system radiochemical portal. They also concern the use of artificial intelligence to interpret measurements by the hodoscope used at the Cabri facility. Regarding openness to society, the two projects chosen concern firstly the evaluation of innovative approaches (Living Lab) to build research on multiple exposure and the related risks, and secondly the involvement of the public in measuring the impact of solar flares on dose rates on board aircraft.

### In brief

#### Sapin II Law

— In the context of the entry into force of the Sapin II Law, in 2018 IRSN continued to deploy the measures necessary for its implementation. These concern deployment of a scheme to protect whistleblowers, the forwarding to the HATVP of information required by law for transparent relations between lobbyists and public authorities, and a risk mapping to identify appropriate measures to fight corruption.

### ZOOM

#### EFFICIENT PROCUREMENT

Procurement contributes to IRSN's efficiency strategy by delivering the most appropriate solution at the best cost, while meeting regulatory, institutional and environmental constraints and complying with ethical and safety rules. The approach also encompasses public procurement performance objectives applicable to EPICs set by the government's procurement department. They are economic performance, access for SMEs to public procurement, integrating innovation, and social and environmental measures. IRSN's procurement was worth €100 million in 2018, particularly in the consulting and business expertise sectors, including research and development, scientific and management computing, and laboratory equipment. IRSN pursued these performance objectives by continuing to pool procurement (with UGAP, DAE, CNRS, CEA, etc.), setting up national framework agreements, inserting social and environmental clauses, giving access to SMEs, and most of all improving economic performance, which is a powerful driver of savings, especially during periods of budget cuts.



In line with proposals stemming from the IRSN 2030 reflection workshops, IRSN has embarked on the «digital transformation» of its internal and external activities with the launch of a digital road map.



### A DIGITAL ROAD MAP

During the collective reflection workshops for the IRSN 2030 initiative, IRSN's need to begin the digital transformation of its internal and external activities was highlighted, with the launch of a digital road map, which should structure the implementation of the suggestions emerging from various workshops.

The digital transformation must meet several challenges aimed at achieving excellence in expert assessment and research, deriving value from data, interacting better with the ecosystem, cooperating better, increasing efficiency and retaining skills.

To achieve this it is based on four principles: making open data the default; testing and learning; having fewer prohibitions for better protection; and cooperating extensively for better validation. The road map consists of nine transformation pathways. In particular, it must ensure better use is made of the data and knowledge acquired by IRSN: sharing data internally to help maintain skills in research, expert assessment and emergency response, while taking account of confidentiality (defense, industrial, personal data, etc.); access to high-quality information for stakeholders and the public. It should also improve efficiency by enabling better use to be made of IRSN's resources.

The first initiatives implemented at the end of the year include the start of deployment of collaborative tools (Skype Enterprise and Teams), internal access to document collections and the drafting of specifications to build an IRSN Lab space.

### ZOOM

#### INTERNAL BAROMETER: STABILITY AND OVERALL SATISFACTION

In early 2018 IRSN published the full results of its fifth internal barometer survey, designed to periodically gauge its internal climate. The results revealed that staff opinions had largely remained stable as regards IRSN's operation and organization. When asked about working conditions, direct management, and communication, and subjects related to IRSN's missions and identity, employees expressed 75% satisfaction, and above 80% satisfaction in the latter case.

The areas where staff would still like to see change are mainly career organization and development and career progression, with on average one in two employees saying they are satisfied. Of all the issues raised in the survey conducted at the end of 2017, two need particular attention and monitoring by IRSN: the perception of workload and the overall issue of pay. Both of these topics are at the heart of IRSN's strategic orientations and will be addressed in the dialog with employees and the agreements negotiated in the next few months.

### A NEW DYNAMIC IN TOTAL QUALITY MANAGEMENT

Having had ISO 9001 certification since 2007, in 2018 IRSN obtained ISO 9001 V2015 certification following audits carried out by Afnor. This achievement is the result of a collective effort to bring IRSN's Quality Management System (QMS) into compliance with this new version of the standard. The auditors welcomed IRSN's drive to improve its QMS. For example, initiatives have been implemented to structure and strengthen the HR process (experts/officers stream, tutoring from the moment new staff join, internal barometer, etc.). The same applies to knowledge and skills management, with the in-house university, which is a genuine inte-

grated training tool. As regards the process related to research activities, many partnerships forged outside the strictly nuclear domain are helping to enrich results and knowledge.

However, this drive must be maintained to consolidate IRSN's strengths and make progress where necessary. IRSN's risk management approach consists of full integration of risk management in the QMS, in keeping with the new version of the ISO standard. It has started work to make sharing and feedback of experience a generalized process so that reporting of internal non-compliances is improved, and has started to look at indicators. Finally, IRSN has also begun to improve the management of its internal audits.

### In brief

— In 2018 IRSN drew up a draft IT system continuity plan (PRAI) to specify the organizational and technical measures necessary to guarantee continuity of operation of part of its IT system. In particular it sets out the conditions for bringing IRSN's servers, which have been off-site since 2014, back to premises specifically designed for them, and also the deployment of an off-site IT backup facility, which will house only applications that need to be restarted quickly.

### IN-HOUSE UNIVERSITY TO DEVELOP SKILLS AND ACCELERATE THE EVOLUTION OF IRSN'S ROLES

At the heart of IRSN's skills management policy the in-house university (Ui) offers tailored training courses covering aspects related to the jobs, culture and working methods specific to IRSN. It responds to a desire to promote, share and transfer IRSN's knowledge and expertise, and thus contribute to the quality of its work and its ability to respond to current and future scientific and technical challenges.

Because of these challenges, a new radiation protection module was introduced, bringing to five the total number of modules: three technical modules (assessment, emergency response and radiation protection), the strategy and management module and the operational support module. New subjects have emerged, particularly in the areas of quality management, knowledge management, intellectual property, governance and strategy, with a first pilot session on November 15, 2018.

In total, 135 training sessions were held in 2018, attended by 1,724 participants and representing more than 17,870 hours of training, dispensed mainly by IRSN's staff.

The Ui is open to external practices and therefore brings in external speakers to share their experience and changes they have made to their practices. In 2018, eight conferences were organized with more than 700 participants:

- a lecture cycle on "emergency response culture", including a speaker from the Paris emergency services (SAMU) on emergency response management in a chaotic world and the lessons learned from the Paris terrorist attacks;
- an information day on the new radiation protection regulations (transposition of European Directive 2013/59/Euratom and security of sources) and discussions with the various organizations involved (Ministries, ASN, IRSN, etc.),
- a cycle of lectures on "Quality of life at work" with a talk by the Patrouille de France air display team to share tried and tested working methods to achieve collective excellence and reduce risk.

Finally, the digital transition and the introduction of artificial intelligence (AI) are transforming the organization of work, generating new skills and causing new roles to emerge. The Ui is a unique forum for discussion and reflection to achieve effective strategic workforce planning in view of these challenges. In 2018 the Ui began a program to raise awareness of changes in management methods with the talk "Managers augmented by AI" (and the associated MOOCs). This training area will be developed in 2019 with the addition of core skills courses and courses for managers and those involved in and supporting the transition.



IRSN's in-house university responds to the desire to promote, share and transfer the Institute's knowledge and expertise.



IRSN's in-house university supports employees' skill and career development with innovative teaching methods.

### ZOOM

#### UPGRADING SUPPORT AND FUNCTIONAL SERVICES AT IRSN

Begun in late 2017, the reflection process on upgrading IRSN's functional and support services aims to reorganize the Institute in order to improve the efficiency and fluidity of its operation and help to improve its overall performance. The work done in 2018, which allowed ample time for discussion and dialog, began with a full diagnostic survey of its perimeter before studying organizational scenarios. Nearly 300 staff from the entities concerned, but also from the operational units, were involved in the process, which involved more than 80 tasks: interviews, immersions, surveys, workshops, etc. The process was discussed with IRSN's governing bodies, and staff and staff representatives were kept regularly informed. It led in the fall to the proposal of a potential target structure, which is currently at the consultation stage with the aim of implementation in 2019.

### In brief

#### Data protection

— In accordance with the General Data Protection Regulation, IRSN worked on the compliance of its personal data processing. In addition to keeping a register of personal data processing and the associated declarations, the designation of a data protection officer was notified to CNIL. The officer relies on contacts within IRSN to organize a proper procedure. Awareness activities have been implemented and an in-house university training course is planned. Finally, IRSN has begun to set up a network with other public institutions to exchange best practices on personal data protection.

#### First step towards an electronic archiving system

— Archive management is part of the digital transition. The successful proof of concept exercise carried out in 2018 on the electronic archiving of virtual invoices is the first of a series ultimately aimed at ensuring IRSN meets its regulatory obligations for conservation of and access to its born-digital documents.

# GOVERNING BODIES

## BOARD OF DIRECTORS AS OF FEBRUARY 1, 2019

### Responsibilities

**Deliberations by the Board of Directors rule on IRSN activities. More specifically, the Board deliberates on general conditions governing the Institute's organization and operation, its strategy and program, and its annual report. It also approves the budget, decisions involving changes, year-end financial statements and income appropriation.**

#### ◦ A member of parliament,

Nomination pending.

#### ◦ A senator

Nomination pending.

#### ◦ Ten government representatives

**Jacques COUSQUER**, Engineer General for Armaments, for the DGA, the French defense procurement agency, representing the Minister of Defense.

**Élisabeth BLATON**, Deputy Head of Nuclear Safety and Radiation Protection at the Technological Risks Department, representing the Minister for the Environment.

**Joëlle CARMES**, Deputy Director of Environmental and Food Risk Prevention at the French Directorate General for Health, representing the Minister for Health.

**Aurélien LOUIS**, Deputy Director for the Nuclear Industry, Directorate General for Energy and Climate, representing the Minister for Energy.

**Frédéric RAVEL**, Scientific Director of the Energy, Sustainable Development, Chemistry and Process Department of the Directorate General for Research and Innovation, representing the Minister for Research.

**Martin CHASLUS**, Head of the Risk Resilience Assessment Office of the Directorate General for Civil Protection and Emergency Response, representing the Minister for Civil Protection.

**Frédéric TÉZÉ**, Subdirectorate for Working Conditions, Health and Safety, Directorate General for Labor, representing the Minister for Labor.

**Diane GEHIN**, Deputy Head of the Energy, Profit-sharing, Industry and Innovation office at the Budget Directorate, representing the Minister for the Budget.

**Alain GUILLEMETTE**, Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities.

**Pierre-Franck CHEVET**, Chairman of the French Nuclear Safety Authority (ASN).

#### ◦ Five advisory members

**Michel FRITSCH**, Air Force Brigadier General, nominated by the Minister for Defense.

**Ginette VASTEL**, doctor of pharmacology, nominated by the Minister for the Environment.

**Marie-France BELLIN**, Chair of the IRSN Board of Directors, Professor of Medicine in Diagnostic and Interventional Radiology at Bicêtre-Pierre-Brousse hospitals, nominated by the Minister for Health.

**Laurent MOCHÉ**, CEO of Edenkia, nominated by the Minister for Energy.

**Fanny FARGET**, Scientific Research Director at the French National Center for Scientific Research (CNRS), nominated by the Minister for Research.

#### ◦ Eight staff representatives

**Nicolas BRISSON**, CGT.

**Laurence FRANCOIS**, CGT.

**Léna LEBRETON**, CGT.

**Patrick LEJUSTE**, CGT.

**Annie CONSTANT**, CFDT.

**Thierry FLEURY**, CFDT.

**Olivier KAYSER**, CFE-CGC.

**Sandrine ROCH-LEFEVRE**, CFE-CGC.

#### ◦ Ex officio or associate members

**Cédric BOURILLET**, Director General of Risk Prevention and Government Commissioner.

**Jean-Pascal CODINE**, Budget Comptroller.

**Jean-Christophe NIEL**, Director General.

**Louis-Michel GUILLAUME**, Deputy Director General in charge of defense-related missions.

**Pierre PIQUEMAL-LAGORRE**, Accounting Officer.

**Philippe BOURACHOT**, Works Committee Secretary.

## STEERING COMMITTEE FOR THE NUCLEAR DEFENSE EXPERTISE DIVISION – CODEND AS OF FEBRUARY 1, 2019

### Responsibilities

**The committee examines the activity program prepared by the Nuclear Defense Expertise Division (DEND) before it is submitted to the Institute's Board of Directors. It is consulted when the Board of Directors is called upon to make decisions relating specifically to the organization or running of this Division and advises the Board of Directors on matters related to division activities.**

**Alain GUILLEMETTE**, CODEND Chairman, representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities.

**François LECOINTRE**, General, representative of the Armed Forces Chief of Staff.

**General Bruno DUVERT**, nuclear weapons inspector.

**Jacques COUSQUER**, Engineer General for Armaments, representing the DGA, the French defense procurement agency.

**Frank MOLLARD**, Colonel, chief of staff of the administrative Secretary, General representing the administrative Secretary General of the Ministry of Defense.

**Adrien BICHET**, representing the Budget Director.

**Clément ARMINJON**, representing the Director of Strategic Affairs, Security and Disarmament at the Ministry of Foreign and European Affairs.

**Christian DUFOUR**, Head of the Economic and Nuclear Infrastructure Security Department, representing the Senior Defense and Security Official of the Ministry of the Economy and Finance.

**Mario PAIN**, Head of the Department of Defense, Security and Economic Intelligence, representing the Senior Defense and Security Official at the Ministry of Ecological and Inclusive Transition.

**Serge POULARD**, Advisory member, appointed by the Minister for Industry.

## SCIENTIFIC COUNCIL AS OF FEBRUARY 1, 2019

### Responsibilities

**The Scientific Council examines and gives its opinion on IRSN activity programs and ensures that its research programs are scientifically relevant and of the highest quality. It examines program results in order to prepare recommendations on Institute strategy. It may be consulted by the Board's chairperson or by the supervisory ministers on any subject that comes under the Institute's authority.**

**Pierre TOULHOAT**, Deputy CEO and Scientific Director of the French Geological Survey (BRGM), IRSN Scientific Council Chairman.

**Jean-Christophe AMABILE**, Chief Medical Officer, associate professor at Val-de-Grâce, Deputy Head of the Defense Health Expertise and Strategy Division of the Central Directorate for Defense Medical Services.

**Robert BAROUKI**, Physician, Biochemist and Toxicologist, Professor of Biochemistry at Université Paris-Descartes, Director of Inserm Unit 1124, Head of Biochemistry, Metabolomics and Proteomics at the Necker-Enfants Malades Hospital.

**Hugues DELORME**, Professor specialized in neutron physics at the School of Military Applications of Atomic Energy (EAMEA).

**Frank HARDEMAN**, Director General of the Belgian Federal Nuclear Control Agency (FANC).

**Guy FRIJA**, Physician, Emeritus Professor of Radiology at Université Paris Descartes, Vice-Chair of the Imaging Committee of Medicen.

**Denis VEYNANTE**, Research director at the French National Center for Scientific Research (CNRS).

**Éric ANDRIEU**, Professor at the Toulouse National Polytechnic Institute (INP).

**Bernard BONIN**, Deputy Scientific Director of the CEA Nuclear Energy Division, nominated by the Minister for Research.

## ETHICS COMMISSION AS OF FEBRUARY 1, 2019

### Responsibilities

**The Ethics Commission is provided for under the IRSN organizational regulations and reports to the Board of Directors. It is responsible for advising the Board on preparing ethical charters that are applicable to the Institute's activities and for monitoring their application, including conditions within the Institute for separating assessment missions performed on behalf of government departments and those performed for public or private operators. It also serves as a mediator when problems of an ethical nature arise.**

**Françoise ROURE**, Chair of the Commission, Chair of the "Safety and Risks" section of the General Economic Council, Economic and Financial Auditor General, Ministry of the Economy, Finance, Public Action and Accounts.

**Lionel BOURDON**, Inspecting General Practitioner, Defense Medical Service (SSA), Defense Biomedical Research Institute.

**Marc CLÉMENT**, Public reporter to the Administrative Appeal Court in Lyon, member of the Environmental Authority of the General Council for the Environment and Sustainable Development.

**Geneviève JEAN-VAN ROSSUM**, Director General of Globalization, Culture, Education and International Development, Ministry of Foreign Affairs and International Development.

**Alexandra LANGLAIS**, Research Officer at CNRS, Faculty of Law and Political Science, University of Rennes 1.

**Mauricette STEINFELDER**, Inspector General, Member of the General Council for the Environment and Sustainable Development and the Environmental Authority.

**Eric VINDIMIAN**, Engineer General in rural engineering, water and forests, Regional Director of the Irstea (French research institute for environmental and agricultural science and technology), specialist in the impact of toxic substances on the environment and health and in assessment of public environmental policies, member of the Environmental Authority and Coordinator of the Research and Technology Commission of the General Council for the Environment and Sustainable Development.

## NUCLEAR SAFETY AND RADIATION PROTECTION RESEARCH POLICY COMMITTEE – COR AS OF FEBRUARY 1, 2019

### Responsibilities

**The Nuclear Safety and Radiation Protection Research Policy Committee, or COR, is an advisory body to the IRSN Board of Directors, giving opinions on research objectives and priorities in the fields of nuclear safety and radiation protection. It adopts a global approach that takes into consideration the requirements of society and the public authorities, complementing the activity of IRSN's Scientific Council, which focuses on the quality and relevance of the Institute's research programs and outcomes from a scientific perspective.**

#### Public authorities

##### + Supervisory ministry representatives:

**Bruno GILLET**, Task Officer, Directorate General for Research and Innovation, representing the Ministry of Research.

**Representative** of the Directorate General for Health, representative of the Ministry of Health, nomination pending.

**Lionel MOULIN**, Head of the Environmental Risks and Health Mission, Research Department, Directorate for Research and Innovation, representing the Ministry for Ecological and Inclusive Transition.

**François-Xavier GOMBEAUD**, Nuclear Safety Inspector for the DGA, the French defense procurement agency, representing the Ministry of Defense.

**Mayeul PHÉLIP**, Task Officer at the Policy and Supervisory Office, Directorate General for Energy and Climate, representing the Ministry for Ecological and Inclusive Transition.

##### + Representing the Directorate for Labor:

**Thierry LAHAYE**, in charge of matters relating to the protection of workers against physical hazards, Directorate General for Labor.

##### + Representative of the French Nuclear Safety Authority:

Nomination pending.

#### Companies and professional associations

**Noël CAMARCAT**, Nuclear Research and Development Officer, Generation and Engineering Branch, EDF.

**Bernard LE GUEN**, Chair of the French society for radiation protection (SFRP).

**Bertrand MOREL**, Research and Development Director, representing Orano.

**Jean-Jacques MAZERON**, Head of the Radiotherapy-Oncology Department, Pitié-Salpêtrière Hospital, representative of the French society for radiotherapy and oncology (SFRO).

**Soraya THABET**, Director of Risk Control and Safety, Andra.

#### Employees in the nuclear sector

##### + Representatives of national labor unions:

**Jean-Paul CRESSY**, FCE-CFDT.

**Martine DOZOL**, FO.

**Claire ÉTINEAU**, CFTC.

**Jacques DELAY**, CFE-CGC.

**Christian HOLBÉ**, CGT.

#### Elected representatives

##### + OPECST representatives:

**Philippe BOLO**, Deputy of Maine-et-Loire

+ 1 nomination pending.

##### + Representative of the Local Information Commissions (CLI):

**Monique SENÉ**, Head of the ANCCLI "Safety" advisory committee, Member of the Saclay CLI.

##### + Representatives of municipalities hosting a nuclear facility, proposed by the Association of French Mayors:

**Bertrand RINGOT**, Mayor of Gravelines.

#### Associations

**David BOILLEY**, President of the association for the inspection of radioactivity in western France (Acro).

**Jean-Paul LACOTE**, representing France Nature Environnement.

**Simon SCHRAUB**, director of the Ligue Nationale Contre le Cancer.

**Lionel LARQUE**, general representative of the Alliance for Science and Society (Alliss).

#### Advisory members

**Jean-Claude DELALONDE**, President of the French national association of local information committees (Anccli).

**Christine NOIVILLE**, President of the High Committee for Transparency and Information on Nuclear Safety (HCTISN).

**Marie-France BELLIN**, Chair of the IRSN Board of Directors, Professor of Medicine in Diagnostic and Interventional Radiology at Bicêtre-Pierre-Brousse hospitals.

#### Research organizations

**Philippe STOHR**, Director of Nuclear Energy, CEA representative.

**Cyrille THIEFFRY**, Task Officer for Radiation Protection and Nuclear Affairs, IN2P3, CNRS representative.

**Daniel FAGRET**, Deputy Director General for Strategy, Inserm representative.

Representative of the French Conference of University Presidents (CPU) nomination pending.

ParisTech representative nomination pending.

#### Foreign members

**Christophe BADIE**, Environmental Assessments Department, Public Health England, United Kingdom.

**Ted LAZO**, Nuclear Energy Agency (NEA), OECD.

#### Ex officio members

**Patrick LANDAIS**, Energy High Commissioner.

**Cédric BOURILLET**, Government Commissioner, represented by Benoit BETTINELLI, Head of the Nuclear Safety and Radiation Protection Mission, Ministry of Ecological and Inclusive Transition.

**Pierre TOULHOAT**, Deputy CEO and Scientific Director of the French Geological Survey (BRGM).

**Jean-Christophe NIEL**, Director General of IRSN.

# GLOSSARY

## A

**ANCCLI** French National Association of Local Information Commissions and Committees.

**ANDRA** French National Radioactive Waste Management Agency.

**ANR** French National Research Agency.

**ASN** French Nuclear Safety Authority.

**ASND** French Nuclear Safety Authority for Defense-related Facilities and Activities.

**ASTEC** Accident Source Term Evaluation Code – a system of computer codes developed collaboratively by IRSN and GRS to evaluate the physical phenomena occurring during a core melt accident in a pressurized water reactor.

## B

**Bel V** Subsidiary of the Belgian Federal Agency for Nuclear Control.

**BRGM** French Geological Survey.

## C

**CABRI** CEA test reactor used by IRSN to study nuclear fuel safety.

**CEPN** French Nuclear Protection Assessment Center.

**CWC** Chemical Weapons Convention.

**CIGEO** Project for a repository in Meuse and Haute-Marne for the reversible geological disposal of radioactive waste.

**CLI** Local Information Commission.

**CLIS** Local Information and Oversight Committee, now known as CSS, Site Oversight Committee.

**CNDP** French National Public Debate Commission.

**CODIRPA** French Post-accident Management Steering Committee.

**COR** Nuclear Safety and Radiation Protection Research Policy Committee.

**CPDP** Special Committee for Public Debates.

**CRITICALITY (RISKS)** Risks associated with uncontrolled chain reactors in fissile materials.

**CTE** Euratom Technical Committee.

## D

**DoE** US Department of Energy.

**DOSIMETRY** Assessment or measurement of the dose of radiation (radioactivity) absorbed by a substance or an individual.

**DSND** Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities.

**DRL** Diagnostic Reference Levels.

## E

**EFFECTIVE DOSE** A physical variable used in the field of radiation protection, where it serves to assess the impact of exposure to ionizing radiation on biological tissue. It takes into

account the sensitivity of the affected tissues and the type of radiation. The sievert (Sv) is the unit of effective dose.

**ENSTTI** European Nuclear Safety Training and Tutoring Institute.

**EPIC** French industrial and commercial public undertaking.

**EPR** Evolutionary Power Reactor (European pressurized water reactor).

**ETSON** European Technical Safety Organisations Network.

**EURADOS** European Radiation Dosimetry Group.

**EURATOM** European Atomic Energy Community.

## G

**GPEC** Strategic workforce planning.

## H

**HCÉRES** High Council for Evaluation of Research and Higher Education.

**HCTISN** High Committee for Transparency and Information on Nuclear Safety.

**HFDS** Senior Defense and Security Official.

## I

**IAEA** International Atomic Energy Agency.

**ICRP** International Commission on Radiological Protection.

**INB** Regulated nuclear facility.

**INBS** Regulated nuclear defense facility.

**INES** International Nuclear Event Scale, graded from 0 to 7.

**INSC** Instrument for Nuclear Safety Cooperation, cooperation contracts financed by the European Commission.

**INSTN** French National Institute for Nuclear Science and Technology.

**ITER** International Thermonuclear Experimental Reactor – Experimental facility and research program to demonstrate the viability of a new energy source: fusion.

## M

**MTES** Ministry of Ecological and Inclusive Transition.

**MICADO** Model Uncertainty for the Mechanism of Dissolution of Spent Fuel in a Nuclear Waste Repository – European project under FP6 on the influence of the uncertainties related to radionuclide release from spent fuel on the overall safety of a geological disposal facility.

**MIRCOM** Ion microbeam used for the radiobiology of intra- and inter-cellular communications.

**MOX** Mixture of plutonium oxide and uranium oxide – Nuclear fuel.

**MWe** Megawatt electric, unit of electric power produced.

## N

**NEA** OECD Nuclear Energy Agency.

**NRA** Japanese Nuclear Safety Authority.

**NRBC** Nuclear, radiological biological, chemical.

**NUGENIA** Nuclear Generation II & III Association, a European association for research on Generation II and III reactors.

## O

**OECD** Organization for Economic Cooperation and Development.

**OPCW** Organization for the Prohibition of Chemical Weapons.

## P

**PARISII** Experimental platform for research into the intake of radioactive substances through ingestion or inhalation.

**PIA/RSNR** French program of investment for the future/Research into nuclear safety and radiation protection.

## R

**RADIOELEMENT** Natural or artificial radioactive element.

**RADIONUCLIDE** Radioactive isotope of an element.

**RES** Test reactor.

## S

**SFRP** French Society for Radiation Protection.

**SISERI** Information system for monitoring exposure to ionizing radiation.

## T

**TECV** French Act of August 17, 2015 on energy transition for green growth.

**TSN** French Act of June 13, 2006 on transparency and security in the nuclear field.

**TSO** Technical Safety Organization.

## U

**UGAP** French Union of Public Procurement Groupings, a public procurement organization.

**UNSCEAR** United Nations Scientific Committee on the Effects of Atomic Radiation.

**US NRC** United States Nuclear Regulatory Commission.

# LEGAL INFORMATION

## PHOTO CREDITS

### o Cover



IRSN's Pearl facility aims to study experimentally the re-injection of water on the debris of a PWR core damaged by a core melt accident. The debris is simulated by 500 kg of metal balls heated by induction, contained in a quartz column more than two meters high in an enclosure, enabling pressurization.

In the photo, IRSN's expert is making a modification to the quartz column to prepare for a new series of tests as part of the PROGRES research program (corium progression and cooling, stabilization of a severe accident).

Credits: Francesco Acerbis/Médiathèque IRSN

### o Inside pages

Pages 6, 8, 11, 13 and 50: Antoine Devouard/Drone Press/Médiathèque IRSN

Pages 19 and 40: Sophie Brändström/Signatures/Médiathèque IRSN

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Pages 32 and 33: Guillaume Bression/Fabien Recoquillé/Médiathèque IRSN

Pages 34 and 43: Noak/Le bar Floréal/Médiathèque IRSN

Page 35: Mazifilm/Médiathèque IRSN

Page 37: Brano Valach/Médiathèque IRSN

Page 38: David Claval/Médiathèque IRSN

Page 42: Francesco Acerbis/Médiathèque IRSN

Page 45: Florence Levillain/Signatures/Médiathèque IRSN

Pages 47 and 53: Stéphanie Clavelle/Médiathèque IRSN

Page 48: Grégoire Maisonneuve/Médiathèque IRSN

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### o Graphic Design and Production

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**Head office**

31, avenue de la Division Leclerc  
92260 Fontenay-aux-Roses  
RCS Nanterre B 440 546 018

**Telephone**

+33 (0)1 58 35 88 88

**Postal address**

BP 17  
92262 Fontenay-aux-Roses cedex

**Website**

[www.irsn.fr](http://www.irsn.fr)

**E-mail**

[contact@irsn.fr](mailto:contact@irsn.fr)



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