IRSN

INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Annual Report 2005

IRSN missions

RESEARCH AND PUBLIC SERVICE MISSIONS

Defining and implementing national and international research programmes

Contributing to training in radiological protection

Permanent monitoring in the field of radiological protection

Contributing to public information and transparency

TECHNICAL SUPPORT AND ASSISTANCE FOR PUBLIC AUTHORITIES

Technical support with regard to nuclear and radiological risk

Operational support in the event of a crisis or radiological emergency

CONTRACTUAL SERVICES IN EXPERTISE, RESEARCH AND MEASUREMENTS

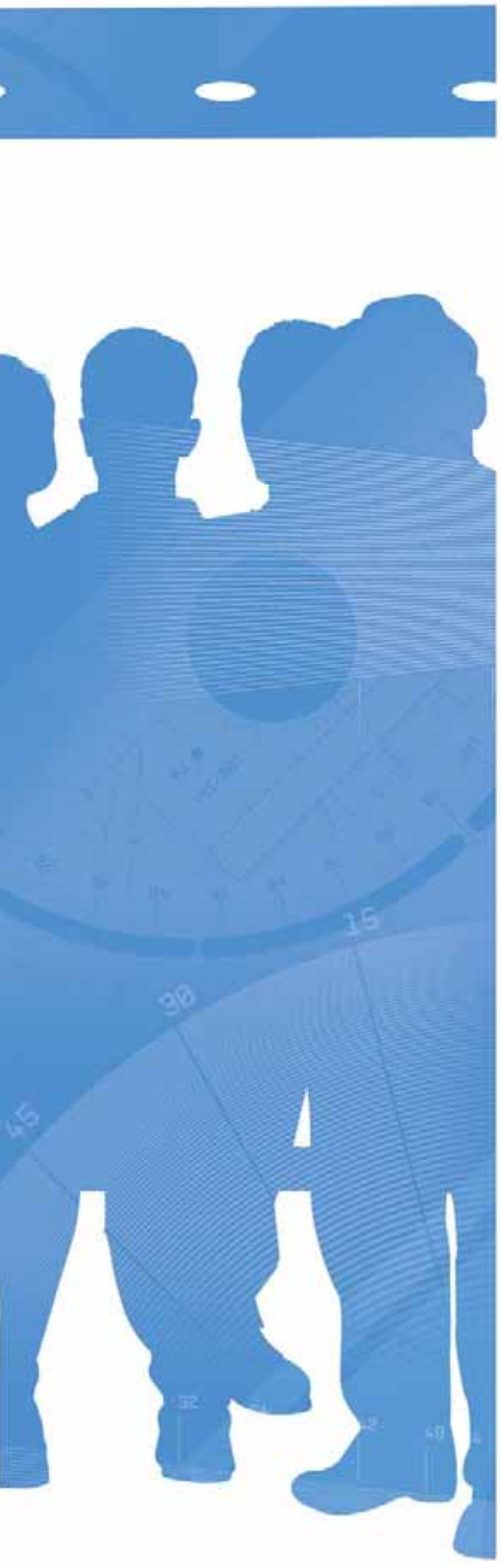
Carrying out expert assessments, research and work for public or private bodies

Annual Report 2005

Current events, strategy and organisation

Management and Support

IRSN Activities



[1]
CURRENT EVENTS, STRATEGY AND ORGANISATION

As a nuclear risk expert reporting to public authorities and a key player in promoting transparency, **the IRSN is preparing for the future**

Jean-François LACRONIQUE,
Chairman of the Board of Directors

Like 2004, 2005 was an eventful year. This report describes events by presenting the main focal points of the Institute's missions, activities and results.

Firstly, on the human scale, 2005 saw the end of the transition period with the CEA and all the Institute's employees coming under the IRSN umbrella. The success of this operation was key to ensuring the long-term nature of our expert assessment and research potential. However, the resulting stability of our situation does not mean that the Institute is no longer looking outward, as the mobility of 170 individuals underlines. This inbound and outbound mobility mainly concerns the nuclear sector (CEA, operators, engineering) and the scientific community (universities, engineering schools) and has also allowed the IRSN to consolidate the presence of its managers on assignments in international institutions (IAEA, EU) and to bolster the number of doctorate and post-doctorate students.

On a financial scale, the IRSN managed to pay off the mortgage burden carried since its creation. Indeed, the change to the Institute's tax status with respect to VAT (all other things being equal) resulted in a return to a break-even situation. Efforts to control and increase revenue at all levels in the Institute helped to consolidate this position. Finally, a solution was drafted in conjunction with supervisory ministries to finance the IRSN's decommissioning costs and specific strategic facilities.

On an operational scale, most targeted objectives were met.
The number of expert assessments delivered in support of government authority operations reached record levels in all areas (operator projects, regulatory changes, international operations, emergency drills, "nuclear material" expert assessments, etc.). By concluding agreements and protocols with these authorities, it was possible to regulate the activity by setting priorities and lead-times, thus enabling key requirements to be met despite a downturn in available resources. An example of this is the expert assessment carried out on ANDRA's *"Dossier 2005 Argile"*, which mobilised several teams and was promptly delivered when required, then published on the Internet in January 2006.
The public interest missions carried out by the IRSN in compliance with its implementing order were carried out with determination and key progress was achieved in many of them: rollout of the SISERI system for radiological monitoring of the workforce, advancements in radiological protection

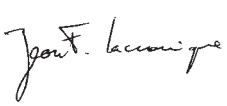
> "The number of expert assessments delivered in support of government authority operations reached record levels in all areas"

training, a twofold increase in the number of connections on the Institute's general public websites over 12 months (over a million connections a year), contributions to public debates on nuclear issues, support provided to the Local Information Commissions (CLI) and their national umbrella association (ANCLI). The Institute also started groundwork with a view to modernising its radiological monitoring systems across France and to upgrading its response procedures and resources in a nuclear or radiological emergency situation.

Significant progress was also made in research: the results obtained in the treatment of severe radiation "burns" saved the life of patient from Chile, who was able to benefit from the world's first stem cell therapy carried out by the Armed Forces Healthcare Department in conjunction with IRSN specialists. *A contrario*, the door to innovating research into low doses was opened following a demonstration of the relevance of research into the effects of chronic contamination (Envirhom project), backed by documentary proof. In terms of security, new programmes were developed in the field of fire propagation (PRISME), and fuel behaviour in an accident scenario (SOURCE TERM). These programmes are jointly financed by a host of partners both in France (EDF mainly) and abroad. The know-how of the Institute's teams, the originality and quality of the experimental resources, whether at the IRSN or related CEA resources, thus continue to bask in international recognition.

Naturally, project commitments must be pursued. The objectives agreement signed on 5 July 2006 is confirmation of the policies adopted over the last three years. A medium- and long-term plan will be drawn up to coordinate the implementation of this agreement and make IRSN research more accessible.
These policies coincide with the law on transparency and nuclear safety recently adopted by parliament: the Institute intends to offer its specialist skills and reliability to the new Nuclear Safety Authority and to public authorities in general. It also plans to effectively handle the missions requested of it by these bodies and particularly the mission regarding research into risks from ionising radiation and nuclear technology. By meeting the expectations of society players and significantly promoting transparency, it intends to contribute to the practical application of the law. Finally, it is planning to play a key role in the European and international processes of growing strategic importance.

Jacques REPUSSARD,
Director General



Jean-François LACRONIQUE,
Chairman of the Board
of Directors

Jacques REPUSSARD,
Director General

The IRSN is a lynchpin in the global challenge for nuclear safety

Michel BRIÈRE,
Deputy Director General, in charge of defence-related missions.

Nuclear safety brings a host of bodies and authorities into play. Nationwide nuclear safety is enhanced by the multi-disciplinary and consistent expertise federated by the IRSN to serve the public sector.

In terms of defence-related nuclear safety on facilities, 2005 was an eventful year in which key projects were performed such as the basin 8 project at the port of Brest, the test reactor in Cadarache and the boiler room of the future *Barracuda*-type nuclear attack submarine.
2005 also saw the re-emergence of safety commissions with respect to laboratories and plants, former test sites, waste and transport, and significant preparation work for emergency situations (four major drills).
But 2005 was also marked by greater contributions to efforts to ensure that nuclear or radioactive materials and their related facilities and transport benefit from extensive protection against the risk of theft, hijack and sabotage.

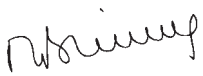
This mobilised experts from the Institute's Division for nuclear defence expertise to check that civilian operators were correctly enforcing the defence code and to ensure France's compliance with its nuclear non-proliferation commitments. This is a priority safety mission which was carried out at the request of national authorities.

Similarly, this division played a key role in the significant work carried out on overhauling regulations in progress since 2002 to enhance safety and provide a more effective documentary resource able to meet the needs of our society in terms of risks from malicious intent and terrorism.

Some of our experts took part in drafting or revising IAEA safety documents, others went on support missions abroad as part of safety programmes under the auspices of the IAEA or the G8. And others are coordinating networks, primarily on a Europe-wide scale, to develop technical capacity with respect to research, measurement and protection of nuclear material.

This evolving capacity to provide expert assessments in the field of safety is underpinned at present by studies on the metrology of nuclear material and the modelling of severe hazards such as the use of explosives or weapons in particular.

The IRSN is a lynchpin in the global challenge for nuclear safety.



Michel BRIÈRE,
Deputy Director General,
in charge of defence-related missions

About the IRSN

CREATION

The IRSN was created by article 5 of law no. 2001 – 398 of 9 May 2001, and by the implementing order of 22 February 2002.

STATUS

The IRSN is a public establishment of an industrial and commercial nature placed under the joint authority of the Ministries of the Environment, Health, Industry, Research and Defence.

EXECUTIVES

Jean-François LACRONIQUE, Chairman of the Board of Directors

Jacques REPUSSARD, Director General

Michel BRIÈRE, Deputy Director General, in charge of IRSN defence-related missions

Philippe JAMET, Deputy Director General in charge of general affairs

EXPERTISE AND RESEARCH

The IRSN is the expert in research and specialised assessments into nuclear and radiological risk serving public authorities.

SCOPE OF ACTIVITY

- Environment and response
- Human radiological protection
- Prevention of major accidents
- Reactor safety
- Safety of plants, laboratories, transport and waste
- Nuclear defence expertise

FOUR LINES OF DEVELOPMENT

- Re-engineering of its research strategy with its main partners
- Optimising missions in support of public authorities
- Making its expertise accessible to meet society's expectations
- Developing the European and worldwid dimension

2005 BUDGET

- Revenues: €287 million
- Expenditure: €268 million, including €26 million in investment

STAFF

The IRSN employs about 1,600 employees including many specialists, engineers, researchers, physicians, agronomists, veterinary surgeons and technicians, skilled experts in nuclear safety and radiological protection and in the field of controlling sensitive nuclear materials.

SITES

Clamart (head office)
Agen, Cadarache, Cherbourg-Octeville, Fontenay-aux-Roses, La Seyne-sur-Mer, Les Angles-Avignon, Le Vésinet, Mahina (Tahiti), Orsay, Pierrelatte, Saclay, Tournemire.

The IRSN in 2005
Report and prospects

Throughout 2005, the IRSN put the strategic policies set out in 2003 by the Director General and approved by the Board of Directors into practice. This allowed the Institute to finish laying the foundations for its quality-based management system and to continue adapting its research facilities as part of the debate on the heavyweight equipment to be maintained and used for research into nuclear safety at international level. The IRSN also finished drafting the objectives agreement signed with the government for the period 2006-2009. This instrument defines the key scientific and technical objectives of the Institute, the most important of which are planned over the medium- and long-term.

IRSN'S MAIN LINES OF DEVELOPMENT IN 2005

1. RE-ENGINEERING ITS RESEARCH STRATEGY WITH ITS MAIN PARTNERS

☐ Promoting scientific and technical production

In 2004, the IRSN organised its first in-house seminar on the theme of scientific excellence. In 2005, its recommendations led to several initiatives being implemented including the drafting of a scientific and technical excellence programme, the organisation of a dedicated committee, a cross-divisional scientific event, training through research and the implementation of a system for assessing the Institute's scientific and technical excellence.

☐ Assessing the scientific and technical excellence of the Institute

The IRSN carried out targeted assessments of its scientific and technical activities: results from a research programme, scientific collaboration, expert assessments, etc. These test initiatives contributed to approving the assessment procedure and to garnering practical feedback for continuing the policy in 2006, particularly regarding the distinction to be made between scientific assessments and assessments regarding the strategic options offered by a programme.

☐ Tailoring research tools

As part of a debate into the heavyweight equipment required for research into nuclear safety to be maintained at international level, the IRSN renovated CABRI, a reactor for testing the safety of nuclear fuel, in 2005. The Institute also set up an international focus group with the objective of fuelling the IRSN/CEA debate on the future of the PHEBUS reactor, which is a test facility for studying damage to a nuclear reactor core and the release of related fission products.

2. OPTIMISING ITS TECHNICAL SUPPORT MISSIONS TO ADMINISTRATIVE AUTHORITIES AND ITS CONTRIBUTION TO PUBLIC POLICY

☐ Formalising the Institute's relationships with the public authorities

In 2005, the IRSN finalised the system to formalise its relationships with public authorities by setting up framework agreements with several government health and safety bodies in particular. Every year, the relevant application protocols specify the content of the activities carried out as part of these agreements. This allows the Institute to better meet the expectations and priorities of public authorities and to better tailor its resources to their requirements and thus improve the efficiency of the overall system of expert assessments.

☐ Modernising the radiological monitoring resources for response operations

In 2005, the IRSN started several initiatives aiming to provide the Institute with more effective resources, including the renewal of the Institute's response vehicles, and preliminary studies into renewing its network for measuring radioactive aerosols. The Institute has continued enhancing its information system for monitoring exposure to ionising radiation (SISERI).

AGREEMENTS SIGNED BY THE IRSN IN 2005

■ **7 June.** Signature of the framework agreement between the Department for Labour Relations (DRT) and the IRSN defining the conditions according to which the IRSN provides its technical support to the DRT with respect to the radiological protection of employees and the procedure for initiating and performing technical support initiatives.

■ **29 June.** At the Seyne-sur-Mer, signature of the 2005 framework agreement defining the terms of the collaboration between the IRSN and Ifremer in national and international study and research programmes in the Mediterranean.

☐ Optimising the use of available resources

In 2005, the IRSN launched a debate into the relative value of its technical support activities to the public authorities. An analysis of its responses to the DGSNR was thus undertaken in conjunction with the latter to focus the available resources on activities producing the highest added value.

THE GOVERNMENT-IRSN OBJECTIVES AGREEMENT 2006-2009

The four-year objectives agreement for the period 2006-2009 drawn up in 2005 aims to structure the strategic approach chosen to enable the IRSN to perform its missions in an optimised manner and define its key scientific and technical objectives. This contract structures the IRSN's activities around the seven challenges listed below and describes the objectives to be achieved in terms of policy effectiveness and the Institute's management instruments.

■ Helping to ensure a high level of safety and radiological protection in existing nuclear facilities until the end of their life.

■ Obtaining the specialist knowledge and resources required for future nuclear facilities in a timely manner.

■ Monitoring the exposure of workers and the public to ionising radiation and monitoring radioactivity in France.

■ Contributing to the fight against the proliferation of nuclear, biological and chemical weapons and to controlling nuclear and radiological safety in the face of terrorism.

■ Developing the IRSN's technical response and mobilisation resources to respond to the risk of a major radiological emergency.

■ Understanding the effects of chronic low-level irradiation.

■ Developing protection against ionising radiation in the medical sector.

3. MAKING ITS EXPERTISE ACCESSIBLE TO MEET SOCIETY'S EXPECTATIONS

☐ Promoting transparency

In 2005, the IRSN continued its policy of making its expertise accessible to the civil society through a host of initiatives involving associations, unions or other specialised institutes. The IRSN became much more involved with the Local Information Commissions (CLI) by responding to requests from the National Association of Local Commissions (ANCLI) regarding nuclear waste management governance, by performing field work with the CLI in the Loire basin and taking part in the public debate on the head-of-series EPR in Flamanville, for which the IRSN drafted "stakeholder's specifications". As part of this contribution, the IRSN recalls that it is involved in work in this area with the ANCLI and the GSIEN (Group of scientists for information on nuclear safety) and that it is planning on continuing its efforts in this area.

☐ Contributing to training in radiological protection

Another IRSN vocation is to provide radiological protection training to healthcare professionals and individuals subject to exposure in their working environment. To provide the most comprehensive training possible, the Institute doubled the number of sessions organised in 2005 so as to reconcile customer satisfaction with optimal quality, both in terms of the teaching strategy and the resources developed to perform it.

4. DEVELOPING THE EUROPEAN AND WORLDWIDE DIMENSION

☐ Contributing to research and European expertise

In 2005, the IRSN decided to respond to the last call for tender issued by the European Union's 6th FPRD by formulating 14 proposals.
As part of setting up a club of technical safety bodies, these founding establishments drew up a joint work programme for assessing the safety of reactors and nuclear facilities, identifying research needs and managing scientific and technical knowledge.

☐ Promoting nuclear safety and security worldwide

At the same time, the Institute launched several key international programmes such as SOURCE TERM, carried out in conjunction with a number of international partners (European Commission, United States, Canada, South Korea, Switzerland, etc.).
The purpose of this initiative is to enhance knowledge about releases potentially occurring in the case of a severe accident with power reactor core meltdown.
The IRSN also contributed to a greater extent to the work of the IAEA, principally by assigning more nuclear protection, radiological protection and nuclear safety specialists to the Vienna branch, and to multi-lateral co-operation carried out within the OECD/NEA *(see box)*. The Institute also participated in some key international support programmes as part of the G8 Global Partnership by contributing to the preparation and performance of initiatives decided upon by Russia and France, such as security at nuclear bases and better monitoring of radioactive sources, the main purpose being to prevent risks of proliferation. The IRSN also took part in international programmes to improve the safety of facilities in Eastern Europe as part of European programmes and the EBRD, mainly with respect to its partnership with GRS.

DETAILS

The OECD's Nuclear Energy Agency (NEA) is an international agency grouping together 28 member countries from Europe, North America and the Asia-pacific region. The NEA's work is carried out by seven technical advisory committees including the Nuclear Facility Safety Committee (CSIN) of which the IRSN is an active member.
The chairman of the CSIN is L. HAHN, Director of GRS, and the Vice-Chairman is P. JAMET, Deputy Director General of the IRSN.
This committee comprises focus groups specialising in the various disciplines (risk assessment, the human factor, severe accidents, etc.) and is coordinating about 15 research projects financed and performed as part of co-operation between the member countries and at the European Commission level. These projects include the CABRI-Water loop (fuel) and PRISME (fire propagation) projects carried out by the IRSN, ROSA and PKL (thermohydraulics) carried out in Japan and Germany, and the MCCI (corium-water interaction) project carried out in the United States.
These three programmes benefit from a French contribution financed by the IRSN.

The IRSN in 2005, a few figures

The Institute's activities

TECHNICAL SUPPORT FOR PUBLIC AUTHORITIES

688 technical notifications to the public authorities (excluding activities relating to defence)

254 notifications to the safety authorities for activities relating to defence

INTERNATIONAL ACTIVITY

100 bilateral agreements signed with research and expert assessment bodies

15 countries involved in these agreements

80 international projects in progress

RESEARCH

50% of the IRSN's budget is devoted to research activities

144 publications in scientific journals, with a proofreading committee

HUMAN RESOURCES

1,675 people employed by the IRSN, with 67 assigned to the DGSNR or other institutions

THE IRSN'S INTELLECTUAL ASSETS

16 French patents in force (including one co-owned with the CEA)

20 patents in force abroad

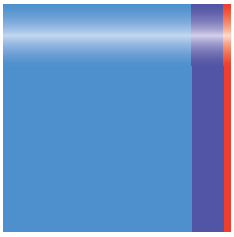
158 software applications and databases listed, 24 of which are co-owned with the CEA

The budget and its breakdown

2005 Budget

Operation/Investment expenditure:

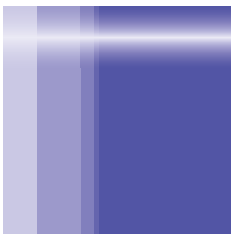
- Operation **91%**
- Investment **9%**



Financing resources:

- LOLF-189 programme subsidy **82%**
- Other French resources **15%**
- Foreign resources **3%**

Other French resources



- Public **15%**
- EDF, research and development **19%**
- Cogema, research and development **6%**
- CEA **2%**
- Others **58%**

Foreign resources

- CCE **30%**
- Riskaudit **39%**
- GRS **4%**
- Epri **6%**
- Others **21%**

Key events 2005

January

27_ Speech by Jacques REPUSSARD, Director General of the IRSN, **on reversible or irreversible storage** in deep geological formations during a public hearing before the Parliamentary Office for Evaluating Scientific and Technical Options (OPECST).

February

15 _ Launch of SISERI, the national dosimetric information system, which centralises information on the individual dosimetry of the 250,000 workers exposed to ionising radiation in France in a database accessible to authorised persons.

21_ Signature of the operating protocol for a technical focus group between the IRSN and Framatome ANP (Areva NP) regarding the ANTARES project for a very high temperature reactor cooled with helium.

March

16/17_ Meeting in London of 10 members of the IRSN's internal stakeholders' network with the Risk Policy Unit team from the Health & Safety Executive (HSE) as part of sharing innovating experiences involving the stakeholders.

16_ Presentation of the Pierre Isoard award to Davide GUERRA, for his thesis work on the modelling of airborne contaminant transfer into ventilated premises close to an accidental emission source.

April

5 _ Introduction of the IRSN into the French National Civilian Security Council, which provides advice about risk prevention, monitoring, warnings, crisis management and initiatives to protect the population.

21_ Presentation to the press of the results from the IRSN's Baromètre 2004 initiative on how the French population perceives risks. This study shows that French people acknowledge the efforts put into reducing certain risks and the quality of the work carried out by scientific experts, but want the scientific community to be more aware of their expectations and to benefit from more comprehensive information which does not conceal differences in interpretation.

May

17_ Patent application to the INPI regarding the use of a new protocol to analyse actinides (uranium, plutonium and americium) in urine aimed at optimising the medical monitoring of workers exposed to a risk of internal contamination.

20 _ Inauguration of two new facilities at the Cadarache site (Bouches-du-Rhône): AMANDE (accelerator for metrology and neutronic applications for external dosimetry) and EPICUR (Experimental Programme on Iodine Chemistry Under Radiation as part of the SOURCE TERM programme).

June

1 _ Start of experimental campaigns: MOZART (study of the oxidation of zircaloy cladding in the presence of air) and BECARRE (study of damage to boron carbide control rods). Both are part of the SOURCE TERM international research programme.

6 _ Approval by the Federation of Post-Graduate Teaching in Radiology (Fepur) for providing radiological protection training to medical and paramedical staff.

July

8_ Ratification of the international agreement on the physical protection of nuclear material (CPPMN) in Vienna.

21_ Publication by the Institute of the final report on the CAROL (Camargue-Rhône-Languedoc) project regarding the observation and study of radioactivity in the environment.

August

12 _ Publication of a new prefectorial order regulating all classified facilities for environmental protection (ICPE) of the IRSN at the Cadarache site (Bouches-du-Rhône).

September

1 _ In conjunction with EDF and the CEA, launch of the international SOURCE TERM programme, in association with the European Commission, Switzerland, the United States, Canada and South Korea.
This research programme aims to limit uncertainty about the assessment of radioactive product releases into the environment in the event of a water reactor core meltdown accident.

9/10 _ National security drill at the COGEMA facility in La Hague.

13 _ Presentation to the press of the conclusions from the FGI (Franco-German initiative) international scientific and technical programme for Chernobyl, jointly coordinated by the IRSN and its German counterpart, GRS.

30_ Approval of the IRSN's Technical Crisis Centre (CTC) following the triggering of the internal emergency plan for the Nogent-sur-Seine (Aube) nuclear facility.

October

1 _ Participation by the IRSN in the public debate organised by the *Cité des Sciences et de l'Industrie* in Paris on the long-term storage of radioactive waste.

24/27 _ Organisation by the IRSN of a conference in Vaux de Cernay with Ulm University and the EBMT (European Cooperative Group for Blood and Marrow Transplantation) on medical response in the case of a radiological accident or terrorist attack.

27 _ Approval by the IRSN's Technical Crisis Centre (CTC) following an incident affecting reactor no. 3 at the Blayais (Gironde) nuclear facility.

November

3_ Commissioning of a new version of the ASTRAL calculation code, developed by the IRSN and cofinanced by EDF.
This code is used to quantify the transfer of radioactive elements into agricultural and forest environments, should a nuclear accident occur causing releases into the atmosphere.

December

12/13_ Presentation to the expert advisory committee of the IRSN's comments on the "*Dossier 2005 Argile*" regarding the feasibility of storing waste in clay geological formations.
The project was drawn up by the ANDRA in application of the law of 30 December 1991 relative to radioactive waste management.

15_ First test carried out at the DIVA facility on fire propagation in a laboratory and plant environment (PICSEL programme).
The results of this programme will contribute to validating simulation software used to forecast the aftermath of an accidental fire in an electrical cabinet on the containment of radioactive material.

IRSN missions

The IRSN's creation order (no. 2002-254 of 22 February 2002) set seven missions for the Institute in terms of radiological protection and nuclear safety. They are grouped into three areas:

RESEARCH AND PUBLIC SERVICE MISSIONS

Defining and implementing national and international research programmes

The IRSN defines and conducts research programmes aimed at maintaining and developing the skills required to carry out expert assessments in its fields of activity. It either carries them out itself or entrusts them to other French or foreign research institutes. Some programmes are carried out in a European or international context.

Contributing to training in radiological protection

As an establishment carrying out research and expert assessments, the IRSN has a duty to contribute to teaching and learning in its field of expertise: nuclear safety and security and radiological protection. The radiological protection training courses it organises are directed at professionals working in the health sector and people exposed to risk in their jobs.

Permanent monitoring in the field of radiological protection

The IRSN is involved in permanent monitoring of radiological protection, mainly by contributing to radiological monitoring of the environment and ensuring the management and use of dosimetric data concerning employees exposed to ionising radiation. The Institute also manages the inventory of ionising radiation sources.

Contributing to public information and transparency

The IRSN informs the public of nuclear and radiological risks via publications, the Internet, a travelling exhibition jointly organised with the DGSNR, conferences, and much more.
With a view to providing transparency in the field of nuclear and radiological risk management, the Institute is continuing its initiatives with the Local Information Commissions (CLI). The goal of these initiatives is to make the IRSN's studies and expert assessments available and to involve the stakeholders as part of pluralistic groups of experts working on the technical challenges generated by complex or controversial subjects.

TECHNICAL SUPPORT AND ASSISTANCE FOR PUBLIC AUTHORITIES

Technical support with regard to nuclear and radiological risk

The IRSN provides technical support in the field of nuclear and radiological risk to the competent public authorities. Its scope covers civilian nuclear facilities, facilities classified as secret, the transport of radioactive substances, the application of treaties on the control of nuclear and sensitive materials and the physical protection and safety of industrial and medical applications. The Institute carries out expert assessment work, research and development, model testing and development, codes and calculation tools in the field of safety and radiological protection.

Operational support in the event of a crisis or radiological emergency

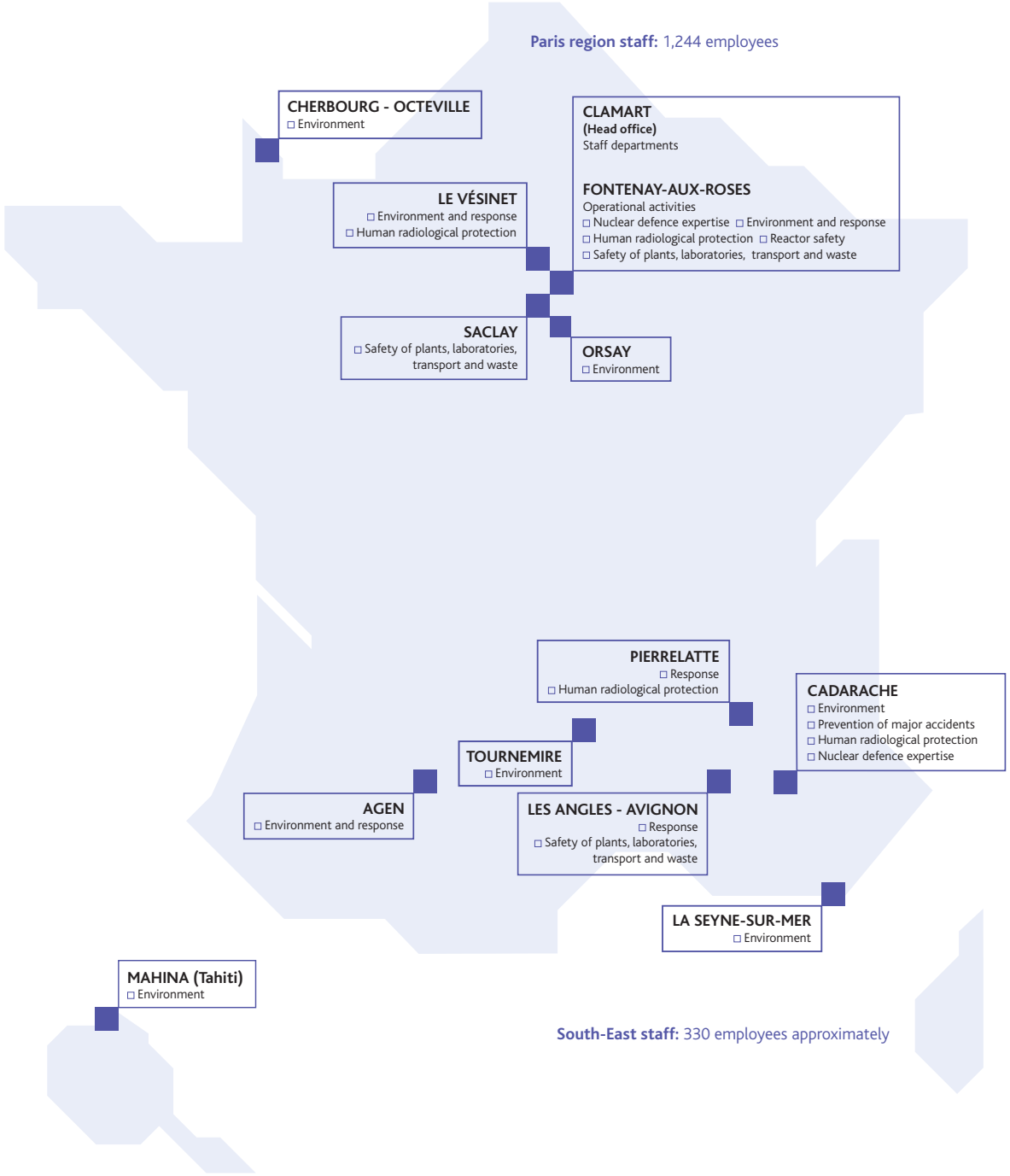
In the event of an incident or accident involving ionising radiation sources, the IRSN carries out technical, healthcare and medical measures for public authorities specific to ensuring the protection of the population, workers and the environment and to resuming a situation of safety on the facilities.

CONTRACTUAL SERVICES IN EXPERTISE, RESEARCH AND MEASUREMENTS

Carrying out expert assessments, research and work for public or private bodies

The IRSN offers contractual services in the fields of expert assessments, research and projects (analyses, measurement and dosing) for French, European and international bodies in the public and private sector. The Institute also provides third-party expert assessments on classified installations for the protection of the environment outside of the nuclear sector.

Sites
Activities and staff



■ **The details for all IRSN sites can be found** on the flap at the back of the report.

The Board of Directors
April 2006

The Board of Directors meets at least four times a year. Through its deliberations, it deals with IRSN business in compliance with article 10 of its implementing order, and particularly the general conditions governing the organisation and functioning of the establishment. It discusses the Institute's programmes and the annual report. In terms of finance, it approves the budget, decisions involving changes, financial statements and income appropriation.

The Board of Directors is made up of 24 members: 10 government representatives appointed by order, including the director general for nuclear safety and radiological protection, and the government representative in charge of nuclear safety and radiological protection, six qualified persons also appointed by order and chosen for their skills in the Institute's area of activity, including a member of parliament or of the French senate, who is a member of the Parliamentary Office for Evaluating Scientific and Technological Options, and eight elected staff representatives from the establishments. The term of office of the board of directors' members is five years which can be renewed once for the six qualified persons.
Five new directors have been appointed since 2005.

□ GOVERNMENT REPRESENTATIVES

Patrick AUDEBERT
Head of the National Mission to support nuclear risk management, representing the Civilian Security Minister

Jean-Denis COMBREXELLE
Director of Labour Relations, representing the Labour Minister

Guillaume SAINTENY
Director of Economic Studies and Environmental Assessment, representing the Ecology and Sustainable Development Minister

Florence FOUQUET
In charge of the nuclear industry sub-division at the Energy and Raw Materials Directorate, representing the Industry Minister

Dominique GOUTTE
Director of the Energy, Transport, Environment and Natural Resources Division, representing the Research Minister

Marcel JURIEN de la GRAVIÈRE
Nuclear safety and radiological protection representative for activities and facilities relating to defence

André-Claude LACOSTE
Director General of Nuclear Safety and Radiological Protection

Jocelyne BOUDOT
Assistant Director for the management of environmental risk, representing the Health and Social Affairs Minister

Frédéric EYRIES
Inspector General for Armaments, representing the Defence Minister

The representative for the budget division will be appointed shortly.

□ EMPLOYEE DIRECTORS

Mireille ARNAUD, Hervé BOLL, Betty CATANIA, Jean-Marc DORMANT, Thierry FLEURY, Dominique MARTINEAU, Xavier MOYA, François ROLLINGER

□ QUALIFIED PERSONS

Jean-François LACRONIQUE
Professor of Medicine, on the proposal of the Health Minister, chairman of the Board of Directors

Claude BIRRAUX
Vice-Chairman of the Parliamentary Offce for Evaluating Scientific and Technical Options

Jean-Marc CAVEDON
Director of the Division for Research into Nuclear Energy and Safety at the Paul Scherrer Institute in Switzerland, on the proposal of the Research Minister

Maurice LAURENT
Former French National Assembly Head of Department, on the proposal of the Industry Minister

Jean RANNOU
Air Force General, on the proposal of the Defence Minister

The qualified person proposed by the Ecology and Sustainable Development Minister will be appointed shortly.

□ LEGAl REPRESENTATIVES

Thierry TROUVÉ
Director of Pollution and Risk Prevention, Government Commissioner

Daniel RACINET
Government Inspector

Jacques REPUSSARD
Director General

Michel BRIÈRE
Deputy Director General, in charge of the IRSN's defence-related missions

Jean-Claude DALE
Accountant

Philippe BOURACHOT
Works Committee Secretary

The Scientific Board
April 2006

The IRSN has a scientific board whose purposes are defined by the Institute's creation decree. The council put forward an opinion concerning the Institute's programmes, assesses their results and can formulate recommendations on IRSN's activity-related policies. Its opinions or recommendations are forwarded to the board of directors and supervisory ministries.
The scientific board issues a written opinion on the Institute's annual report, and it can be consulted by the board of directors' chairman or by supervisory ministries regarding all research in the establishment's areas of skills. Its opinion may be requested on all issues or actions involving by the IRSN.
In 2005, the scientific board held two plenary meetings (in May and November) during which it gave in particular its opinion on the Annual Report 2004 and on the Scientific and Technical Report 2005.

These meetings also included visits to some facilities (such as CABRI and AMANDE in Cadarache or the DEI/SARG facilities in Fontenay-aux-Roses) and were an opportunity for the board to gradually become informed of the different aspects of the IRSN's research programmes and organisation. As indicated in the board's rules of procedure, more specific assessments are carried out by commissions created on the joint initiative of the board and the IRSN. The commission devoted to studies and research carried out by the Institute into the deep storage of radioactive waste held its first meeting on 21 September 2005 and should continue its work in the first quarter of 2006. A second commission, dedicated to the IRSN's work into reconstructing the fallout of the Chernobyl accident in France, will carry out its work at the beginning of 2006.
The scientific board is composed of 12 members chosen according to their scientific and technical skills and appointed for five years by the joint order from the supervisory ministers of 6 July 2004.

Chairman: Michel QUINTARD
CNRS Research Director at the Fluid Mechanics Institute in Toulouse, on the proposal of the Research Minister

Bernard SEVESTRE
Engineer General for Armaments, Deputy Director at the French Atomic Energy Commission, on the proposal of the Defence Minister

Martin SCHLUMBERGER
Professor of Medicine, head of department at the Gustave Roussy Institute, on the proposal of the Defence Minister

Ethel-Esther MOUSTACCHI
Scientific Director reporting to the High Commissioner for atomic energy, on the proposal of the Environment Minister

Victor TESCHENDORFF
Head of Department at *Gesellschaft für Anlagen und Reaktorsicherheit* (GRS / Germany), on the proposal of the Environment Minister

André AURENGO
Professor of Medicine, head of department at the Pitié-Salpêtrière hospital, on the proposal of the Health Minister

Jean-Marc COSSET
Professor of Medicine, head of department at the Curie Institute, on the proposal of the Health Minister

George YADIGAROGLU
Professor of Nuclear Engineering at the Swiss Federal Institute of Technology, on the proposal of the Industry Minister

André PINEAU
Professor at the Paris *Ecole des Mines*, on the proposal of the Industry Minister

Philippe LECONTE
Physicist, former director of the CEA's radioactive waste management research programme, on the proposal of the Research Minister

René AMALBERTI
Professor of Medicine, head of department at the Aerospace Medicine Institute, on the proposal of the Labour Minister

Lars-Erik HOLM
Professor of Medicine, director general of the Swiss Authority for radiological protection, on the proposal of the Labour Minister

Organisation chart
April 2006

BOARD OF DIRECTORS

Jean-François LACRONIQUE, Chairman

FUNCTIONAL DIVISIONS

Division for Strategy, Development and External Relations

Michel BOUVET*, Director

Deputy Director in charge of external relations:
Jean-Bernard CHÉRIÉ
Deputy Director in charge of programmes:
Yves SOUCHET

- Research programmes
- Expert assessment programmes
- Society awareness
- International relations
- Secretariat for advisory committees

Division for Scientific and Technical Evaluation, and Quality

Joseph LEWI, Director

- Radiological protection training
- Assessment and scientific activities
- Quality management
- Health, safety and environmental protection
- Scientific and technical knowledge engineering
- Scientific information resources

General Secretariat

Jean-Baptiste PINTON, General Secretary

- Financial affairs
- Human resources
- Commercial relations and legal support
- Property management and general services
- Information systems administration

Communications Division

Marie-Pierre BIGOT, Director

- In-house communication
- Information to the press and press relations
- Public relations and programmes

* From 1 January 2006.

GENERAL SERVICES

Accounting Office

Jean-Claude DALE, Accountant

GENERAL MANAGEMENT

Jacques REPUSSARD, Director General

Michel BRIÈRE, Deputy Director General in charge of the IRSN's defence-related missions

Philippe JAMET, Assistant Director General in charge of general affairs

OPERATIONAL DIVISIONS

Division for Nuclear Defence Expertise

Jérôme JOLY, Director

- Application of international controls
- Technical support to public authorities and studies
- Assessment of defence-related safety
- Safety of nuclear facilities

Division for Human Radiological Protection

Patrick GOURMELON, Director

- Radiological protection studies and expert assesments
- Radiobiology and epidemiology
- External dosimetry
- Internal dosimetry

Division for Environment and Response

Didier CHAMPION, Director

- Study into the behaviour of radionuclides in ecosystems
- Study and monitoring of radioactivity in the environment
- Analysis of risks related to the geosphere
- Sample processing and metrology for the environment
- Radiological protection response and support
- Emergency situations and crisis organisation

Division for Reactor Safety

Martial JOREL, Director

- Pressurised water reactors
- Gas-cooled, fast neutron and test reactors
- Materials and structures
- Systems and risks
- Thermohydraulics, cores and the running of facilities
- Severe accidents and radiological consequences
- Human factors

Division for the Prevention of Major Accidents

Michel SCHWARZ, Director

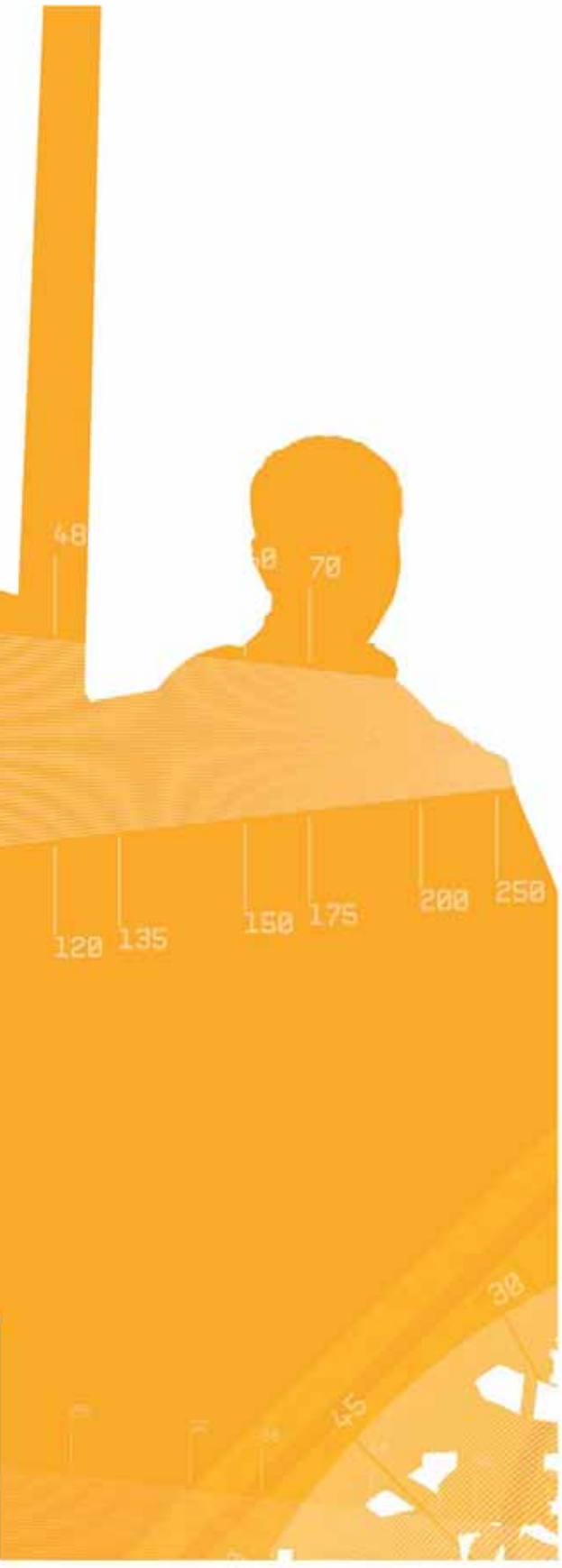
- Studies and experimental research into accidents
- Experimental instrumentation and engineering
- The study and modelling of fuel in accident scenarios
- Fire, corium and containment studies and modelling

Division for the Safety of Plants, Laboratories, Transport and Waste

Thierry CHARLES, Director

- Fuel cycle transportation and facilities
- Laboratories, irradiators, accelerators and decommissioned reactors
- Radioactive waste
- Industrial, fire and containment risks
- Criticality
- Airborne dispersal of pollutants


20
42
90
105



[2]
MANAGEMENT AND SUPPORT

MANAGEMENT AND SUPPORT

To enhance the quality, pertinence and clarity of the initiatives carried out daily by its teams as part of its scientific, technical and operational programmes, the IRSN performs a series of cross-divisional functions in the fields of scientific and technical excellence, health and safety at work, quality, communication and human resources.

The Institute assesses the professional risks to which its employees are exposed by focusing on changes to the legal and regulatory framework in this area. It is developing a quality-based management system with the objective of obtaining ISO 9001 certification by 2007 and is continuing its policy of communication with a view to raising awareness about its activities and skills. Finally, the Institute is pursuing its efforts to improve employee efficiency through training and career management.

Scientific and technical excellence

The IRSN's policy of scientific and technical excellence is based on promoting this excellence, setting up a system of assessing the Institute's activities from a scientific and technical standpoint and evaluating the activities contributing to the IRSN's reputation. In the field of scientific and technical knowledge engineering, the IRSN's activities focus on two key areas: information on scientific and technical questions and archive management. In 2005, several initiatives were implemented to facilitate and widen access to the scientific and technical documentation required by the IRSN's engineers and researchers to perform their missions.

23 agreements signed with universities, engineering schools or the CNRS

11 km of archives

The COXST committee dedicated to scientific and technical excellence

This committee was set up in 2005 and debates, analyses and monitors the direction taken in terms of the policy of scientific and technical excellence, recommendations resulting from the scientific and technical assessments carried out by the Institute or by the Scientific Board, and initiatives with respect to scientific communication. Within the IRSN, it carries out initiatives to promote, assess and acknowledge the excellence of the Institute's activities and teams.

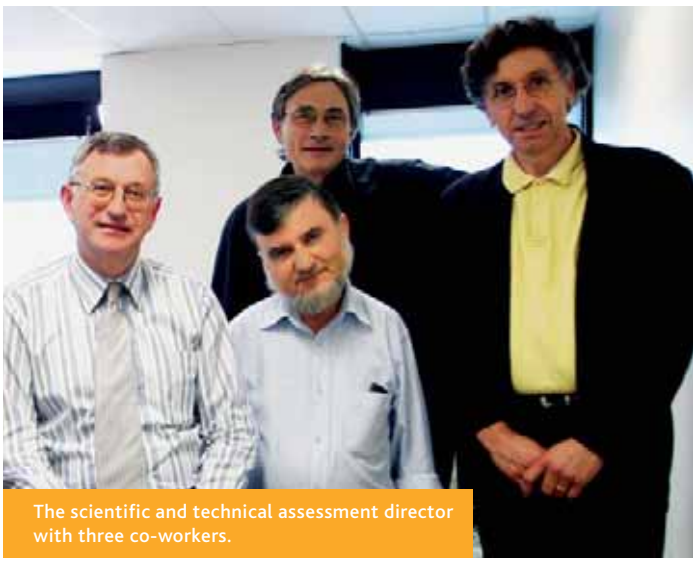
Implementation of the scientific and technical excellence programme

This programme was set up in 2004 and groups together the cross-divisional or generic initiatives contributing to achieving excellence in the IRSN's programmes and to the promotion and evaluation of its skills and work. Its content focuses on specific activities which are not part of the Institute's other programmes:

- training through research and teaching;
- scientific activities;
- scientific and technical assessments;
- scientific and technical communication;
- exploratory research.

"Targeted" test assessments

A "targeted" assessment consists of objectively analysing a specific activity to obtain a pertinent representation which allows an opinion and recommendations to be formulated. The assessment may focus on any of the IRSN's scientific or technical activities (services, expert assessments, research, studies). They are conducted by experts who have not been involved in the activity in question and from outside the Institute if possible. Test initiatives were launched on different topical areas in a bid to establish the type of questions to be asked and practical procedures regarding the



The scientific and technical assessment director with three co-workers.

assessments carried out with the teams concerned: the findings from a research programme, the refocusing of this programme, scientific collaborations, expert assessments of safety, a team, etc. These test assessments were used to check the approach out and update knowledge for future assessments. They have shown that the structuring phase carried out by the assessment with the relevant team is essential to correctly defining the elements to be taken into account to ensure its effectiveness. They have also highlighted the difference between a scientific assessment and an assessment of strategic options regarding a programme, and the difficulty in evaluating an expert assessment activity without having recourse to a second assessment.

At the end of the year, the divisions isolated about 15 subjects which may undergo a scientific and technical assessment in 2006-2007.

Global scientific and technical assessment: setting up indicators

The indicators fulfil a three-fold function: they are the in-house tools used to achieve improvement objectives, they help to clarify the IRSN's stance with respect to outside society, and they contribute to the acknowledgement of the scientific and technical quality of its work.
A comprehensive set of criteria has been established to define indicators for monitoring developments in scientific and technical excellence, at the level of the units and general management.
The indicators used for scientific and technical assessments must be consistent with those implemented as part of the French Organic Law relative to Finance Laws (LOLF) or the objectives agreement. The Institute has also undertaken to actively participate in a project to produce indicators for the purpose of comparisons with national research.

Implementation of a cross-divisional scientific and technical activity

In-house scientific and technical activities aim to promote knowledge-sharing and to better identify, coordinate and take advantage of the cross-divisional initiatives in the operational units. The first activity group was set up in 2005 to focus on radiation-material interaction codes as part of using the Monte Carlo codes.
The objectives of this group were drawn up into five points at the launch seminar held in September:

- identifying, learning and implementing the best methods and practices;
- sharing and upgrading technical skills;
- enhancing knowledge on the use of calculation codes;
- raising awareness about procedures and validation methods for the calculation results;
- preparing for the future.

The central level of the division for scientific and technical knowledge engineering.

Exploratory research: definition and application procedures

Helping researchers to express their creativity to benefit future IRSN programmes is the objective of exploratory research. The Institute thus set up a focus group in October 2005 composed of representatives from the various divisions. This group drafted a definition of exploratory research and the proposal, selection and implementation procedures to be used.

Relationships with universities and scientific organisations

These are essential for a research body like the IRSN. Indeed, although Institute research is focused on acquiring knowledge through expert assessments, independent experts should be allowed to give their opinion on this research, and to critically analyse, evaluate and enhance it by putting forward new ideas. The relationships with universities are a primary way of developing and improving IRSN skills. By allowing professionals from the Institute to contribute to the training given at the universities and engineering schools, these links are a way of enhancing the Institute's reputation, attracting young blood and fulfilling its duty to pass on its knowledge through teaching and training.

The studies carried out in conjunction with universities, engineering schools and CNRS laboratories are drawn up into co-operation agreements covering joint research projects and the acceptance of trainees. In 2005, co-operation agreements were signed with different universities and schools *(see Focus opposite)*. As part of a national co-operation agreement signed in 2003, 11 specific agreements were signed with different CNRS laboratories. They cover varied topics such as mass spectrometry at high temperatures, tension creep of concrete, analysis of the thermomechanical behaviour of fuel cladding, and the modelling of radiation transfer in a porous environment.

The publication policy debate

A debate was conducted on the IRSN's policy in terms of scientific and technical publications. The Institute has an obligation to publish articles in approved scientific journals in its fields of activity (research and expertise) to show the value of its findings. Time should be allowed for this in its programmes.

[FOCUS]

Agreements signed in 2005 between the IRSN and universities, engineering schools or the CNRS

Collaboration framework agreements with:

- the Méditerranée Aix-Marseille 2 University – 11 August 2005
- the Joseph Fourier University in Grenoble – 17 October 2005
- the Paris XII University – 17 November 2005

Specific collaboration agreements with:

- Havard University – 17 January 2005
- The *Ecole des Mines* in Saint-Etienne – 20 October 2005
- The *Ecole Nationale Supérieure de Chimie* in Paris – 18 November 2005

Six specific agreements with the Armines laboratories

Specific agreements with CNRS laboratories:

- IMF (Fluid Mechanics Institute) in Toulouse – 9 February 2005
- Civil Engineering and Building Department at the ENTPE (National Engineering School for Government Civil Engineering) in Vaulx-en-Velin – 10 March 2005
- Géosciences Azur – 21 March 2005
- LaMCoS (Contact and Solids Mechanics Laboratory) at the INSA (National Institute of Applied Science) in Lyons – 22 April 2005
- EM2C (Molecular and Macroscopic Energy and Combustion Laboratory) at the *Ecole Centrale* in Paris – 23 May 2005
- CEREGE (Management Sciences Research Centre) in Poitiers – 27 July 2005
- LPM2C (Laboratory for the Physics and Modelling of Condensed Media) in Grenoble – 9 August 2005
- LSGC (Science of Chemical Engineering Laboratory) in Nancy – 23 August 2005
- LMGC (Mechanics and Civil Engineering Laboratory) in Montpellier – 29 August 2005
- LTCPM (Laboratory for Metallurgical Thermodynamics and Physics-Chemistry) at the *Ecole Nationale Supérieure d'Electrochimie et d'Electrométallurgie* in Grenoble – 18 November 2005
- LMT (Mechanics and Technology Laboratory) at the *Ecole Normale Supérieure* in Cachan – 29 November 2005

FOCUS

Training through research: encouraging results

Effective collaboration between academics and researchers.

Thesis supervision is an opportunity for the IRSN to maintain close links with the academic community as most theses prepared within the Institute are under the supervision of external researchers.
The IRSN thus undertook a policy of training through research in 2004. The benefits of this policy became apparent with 27 new doctorate students taken on in 2005, as against 18 in 2004.
At the same time, about 20 recent thesis graduates are rounding out their training by following a post-doctorate training course at the IRSN. A reasonable number of them will then be recruited by the Institute(1).

Moreover, the Institute is encouraging its researchers to support its eligibility to supervise research (HDR) policy, thus showing its willingness to open up to the world of university research.
In 2005, three new HDRs were delivered to IRSN researchers.

(1) 4 out of the 8 students who vivaed their theses in 2004 were employed by the IRSN.

Training through research, teaching and publications: publication of annual reports

The IRSN set up an organisation allowing it to publish annual reports on training through research, teaching and publications. Many of the figures published in this annual report come from these reports. *(see Focus opposite)*

Scientific communication: restructuring of the IRSN's scientific website

The goal of the IRSN's scientific website (**www.irsn.org/net-science**) is to inform the scientific community about the teams and the work carried out by the Institute. In 2005, it was restructured and its graphics improved to provide greater clarity and simplified access to information. This new look site was online in July and generated its first positive results with a 40% rise in the number of connections between 2004 and 2005.

Scientific publications: two books published in 2005

The IRSN publishes a collection of scientific books. The translation of an ICRP document published at the end of 2004, a guide for medical practitioners entitled *Vos patients et les rayons* (Your patients and radiation) was a tremendous success with 4,000 copies issued on request to the medical community. Two other books were published in 2005. The first was a French translation of publication 91 by the International Commission on Radiological Protection (ICRP) entitled *Cadre méthodologique pour évaluer l'impact des rayonnements ionisants sur les espèces*

Publications to share the IRSN's scientific knowledge.

non humaines (Methodological framework for assessing the impact of ionising radiation on non-human species) (collection *Lignes directrices*). The second, entitled Scientific trends in radiological protection of the environment, is a collection of contributions by speakers from the Ecorad 2004 congress.

IRSN archives: inventory finalisation

The archive inventory ended in 2005 with the formation of a database enabling searches to be carried out across the 11 km of the Institute's archives and the acquisition of a new archive management software. Historians can thus now use the IRSN's historical archives. A debate is also under way regarding electronic archiving.

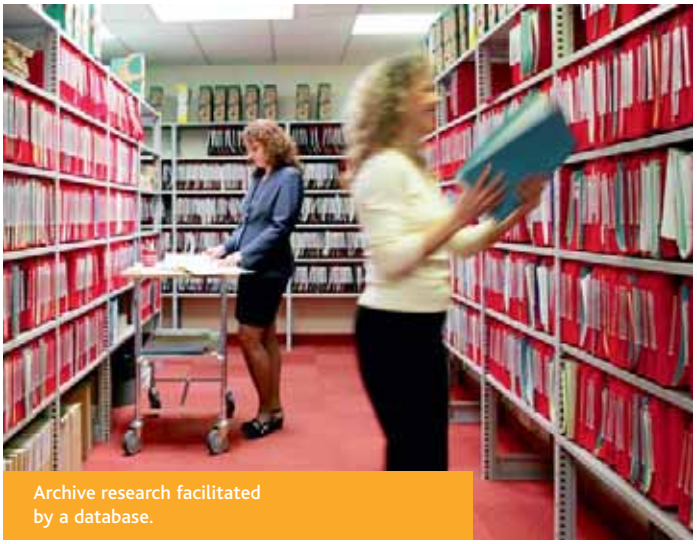
Wider electronic access to scientific and technical documentation

The scientific information resource centre (Cris) can be used by all staff and now proposes the full text of scientific and technical documents from several hundred electronic reviews to the entire Institute. Two new bibliographic databases, one offering full texts, have been put online.

Moreover, the Cris' new bibliometric database now indicates the impact factor of international scientific reviews thus helping researchers to optimise their publications. Dialog, the database query portal, has been enhanced, four patent bases have been added and six Afnor reference standards can be consulted online. This information is available to all staff on the intranet. In addition to this, a new documentary management software can be used to consult references from the Cris' document base on the intranet.

The Cris has provided information about the tools and services on offer to the different divisions through presentations and a mini-guide of which 500 copies were issued.

Scientific and technical documents available to all staff.



Archive research facilitated by a database.

Capitalising on scientific and technical knowledge: launch of the preparation phase

The objective of this project is to set up a tool allowing all IRSN employees to quickly locate a required document from those produced by the Institute, while complying with the rules governing information availability and circulation. In 2005, the Institute carried out the preparatory phase of the project by producing three reports entitled respectively: *Inventaire des outils et projets existants en gestion des connaissances* (Inventory of existing tools and projects for knowledge management), *Proposition d'une stratégie pour un système de gestion des connaissances et analyse du besoin* (Proposal of a strategy for a knowledge management and needs analysis system) and *Faisabilité du projet de capitalisation: périmètre, architecture fonctionnelle et organisation* (Feasibility of the capitalisation project: scope, functional architecture and organisation).

Quality

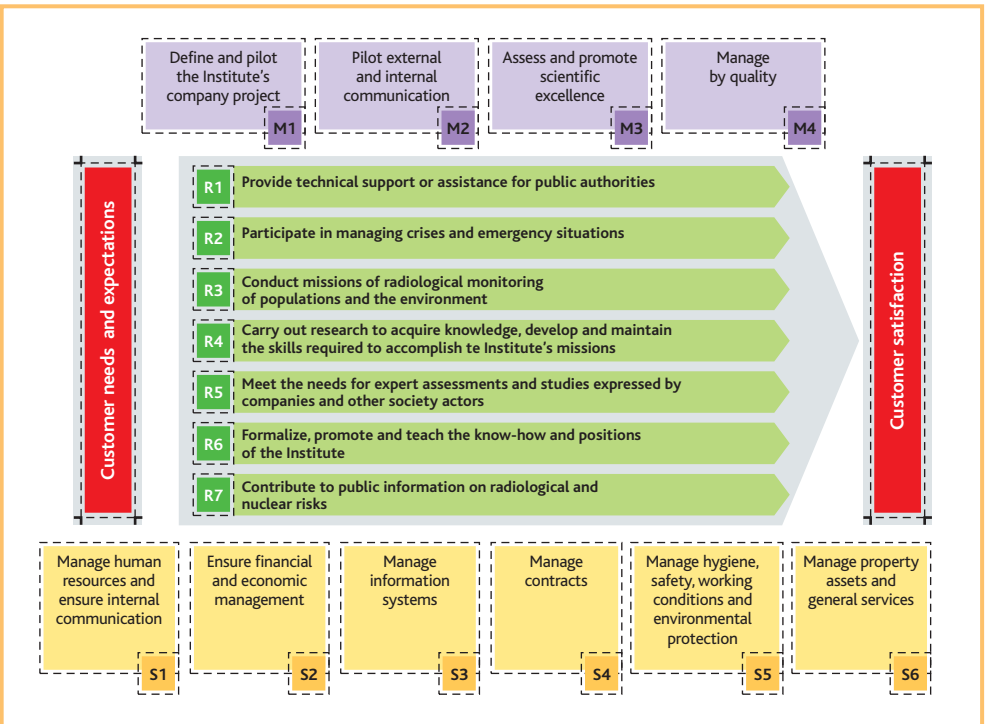
The IRSN's Certification project launched in the summer of 2003 is continuing with the goal of obtaining ISO 9001 certification by 2007. The groundwork for the Institute's quality-based management system was finalised in 2005, allowing the development of macro-processes (which represent the Institute's main lines of activity) and the processes comprising them.

The development of the IRSN's macro-processes involves work on describing processes. This is highly important inasmuch as the missions that they will be used for will cover several divisions of the Institute. It comprises the following three stages:

- examination of all IRSN unit activities and the breakdown of these into the Institute's 17 macro-processes *(see diagram below)*;
- identification of the interfaces between macro-processes;
- definition of the processes making up each macro-process;
- definition of both pertinent and realistic objectives, and indicators for appraising the achievement of these objectives;
- identification of the critical points for the functioning of processes and definition of the related control provisions.

The following actions were also carried out in 2005:

- continued training and communication efforts, mainly through conducting three half-day information seminars on quality-based management at the Institute's main sites, the start of a series of "how to be audited" training courses for preparing



IRSN process mapping.

Policy to achieve approval to become an "organiser of interlaboratory comparisons"

[FOCUS]

IRSN standards and intercomparison laboratory.

In 2005, the IRSN's division for sample processing and environmental metrology (Steme) saw its "*Cofrac Essais*" approvals renewed and acceptance of the requested extension concerning the determination of uranium isotopes in water, according to the benchmark from standard NF EN ISO/CEI 17025, for the programmes 135 and 99-4.
The policy was pursued with a view to obtaining Cofrac approval for the Steme as an "organiser of interlaboratory comparisons" in 2006. To ensure that the criteria in the standard were met in full, the laboratories dedicated to this activity were reorganised, and special software for managing interlaboratory tests was developed.
Following a blank audit in June 2005, the initial approval application was filed with the Cofrac in July. This approval will be the acknowledgement of IRSN's organisation and technical skills in this field.

Cofrac approval offers customers a guarantee of the quality of the services provided. As a signatory of the European multilateral agreement relative to mutual recognition of tests, calibration and certification and relative to equivalent international agreements, the Cofrac also opens the door to exportation.
These approval policies coincide with the IRSN's certification policy. Indeed, the requirements regarding the content management system in standard NF EN ISO/CEI 17025 comply with the principles laid down in the ISO 9001 version 2000 standard.

agents for the certification audits, the circulation of a brochure to staff presenting the main aspects of the "certification" project and a first edition of the IRSN's quality manual, and finally the circulation of a quarterly information bulletin for staff on project progress;

- on 30 November 2005 the drafting of an IRSN management review, preceded by IRSN unit (divisions and departments) management reviews. These reviews allowed the action plans for 2006 to be drafted at the different line management levels. These plans cover the project phase, from the second half of 2005 until the "blank" audit (autumn 2006), which should be the opportunity to perform an overall assessment of the new quality-based management system prior to certification application.

"QUALITY" AUDITS IN 2005

About 30 internal audits were carried out at the IRSN in 2005, including seven cross-divisional audits. From now on, the audit programmes will be developed so as to be able to audit each of the Institute's 100 constitutive processes at least once over a three-year period.

Moreover, the training of new auditors recruited in 2004 was virtually carried out in full. Some have already taken part in audits.

Health and safety at work

Safety, working conditions and healthcare in the workplace are priority issues for the IRSN. The Institute's policy in this field, which was circulated to staff in May 2005[2], has been drafted into an annual prevention programme drawn up on the basis of an assessment of professional risks and analysis of changes to the legal and regulatory framework.

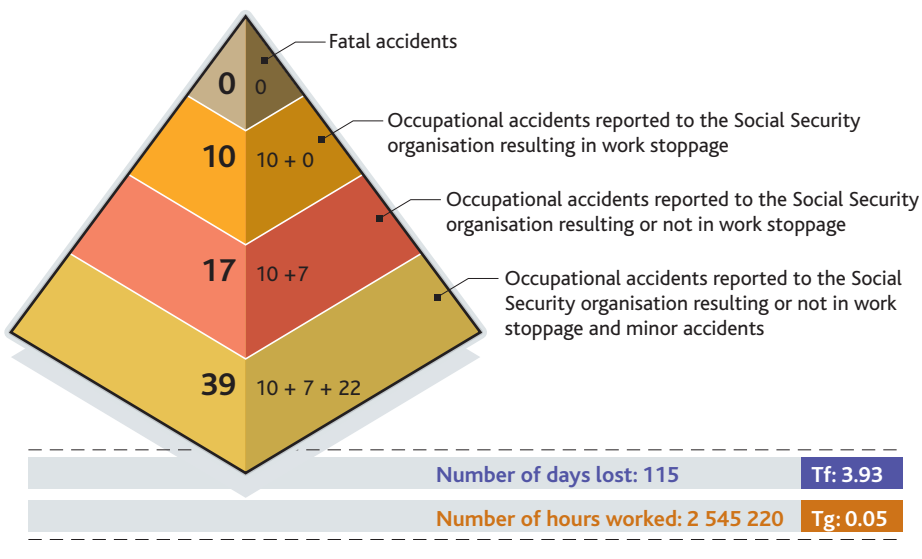
Professional risks

The identification and results from the assessment of risks to which employees are exposed at their workstations were drawn up into a single document for each IRSN site.

The assessment includes all risks and particularly exposure to ionising radiation and carcinogenic, mutagenic and toxic chemical products with respect to reproduction. The unit managers are using this document to set up prevention initiatives also focusing on staff training, projects or the purchase of personal protective equipment.

Updating personal exposure records

The risk assessment led the IRSN to update the content of employee personal exposure records to include information regarding accidental exposure. This record allows the occupational physician to carry out preventive medical monitoring tailored to the specific nature of each workstation. As this is kept in the employee's medical file after departure, it is also a way of creating a record of his/her professional exposure.



The national health insurance fund has defined two national indicators:
- **frequency rate (Tf):** number of occupational accidents with work stoppage per one million of hours worked
- **severity rate (Tg):** number of days lost per one thousand of hours worked

Pyramid of accidents occurring in the workplace at the IRSN in 2005.

(2) Brochure circulated in-house and published on the HSE intranet.

Upgrade of facilities: investment of €4.9 million in 2005

Work to upgrade facilities from a technical and regulatory standpoint was carried out in the facilities most exposed to electrical risks and fire risks. In Le Vésinet in particular, the conformity of electrical facilities and ventilation systems in laboratories measuring radionuclides in the environment was upgraded.

Specialised entities carried out searches for asbestos presence and analysed material condition. These diagnostics led to the creation of technical "asbestos" files and confirms the presence of asbestos in most older facilities, which thus require monitoring, withdrawal or containment operations to be carried out.

Risk prevention and first aid: staff training

Over 2,000 IRSN employees received safety training in 2005, reporting a rise of 64% on 2004, with a greater focus on first aid response in an emergency. This general training was complemented by specific training on raising management awareness on the issues of health, safety and protection of the environment.

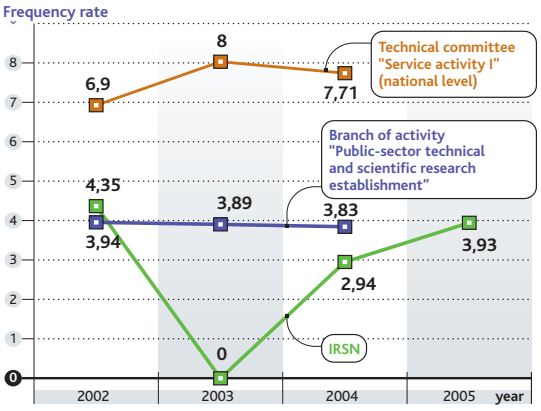
Radiation protection: adapting to regulatory changes

The Institute undertook several initiatives to implement the order of 31 March 2003 relating to workforce protection. In particular, it appointed radiation protection specialists to cover all of its sites and set up a regulatory inspection programme for its facilities and radiation sources carried out by an approved body. The Institute set up protocols to allow the radiation protection specialists and occupational physicians to access results from staff dosimetry tests recorded on the national SISERI system.

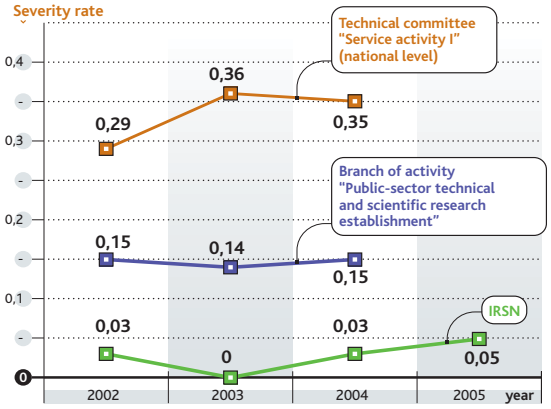
Preparing for incidental and accidental scenarios

The IRSN has a system whereby management can be informed on a 24-hour basis of any event occurring in the facilities and which may endanger personnel, property or the environment of the Institute, and whereby the relevant authorities can be duly informed thereof.

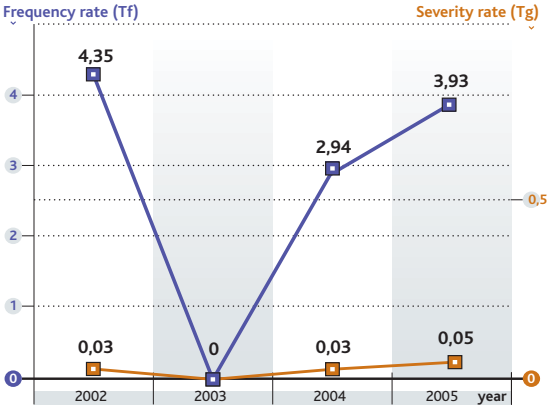
Comparison of frequency rates



Comparison of severity rates



Change in Tf and Tg at the IRSN



Setting up of a central health and safety committee

The corporate agreement signed in May 2003 by IRSN management and unions provides for the existence of a central body composed of management and staff representatives. With its global remit covering all sites in terms of health, safety and staff working conditions, this body met for the first time on 3 May 2005, thus fuelling the Institute's system for improving its results in environmental safety and protection.

IRSN internal practice and procedures: definition of applicable rules

On 25 May 2005, the management rolled out the Institute's internal practice and procedures, which is a document defining the rules which employees and staff must implement in terms of security.

Internal practice and procedures to define the rules governing safety in particular.

Controlling the effects on the environment

In this specific area, the Institute ensured that the number of radioactive sources in its possession was reduced to an absolute minimum in 2005, and thus eliminated 950 of the 1,000 sources not in use, inherited on its creation.

Stricter security rules for the ICPE and a reduction in dangers at source

On 12 August 2005, the prefect of the Bouches-du-Rhône department signed an order regulating all the IRSN's facilities classified for environmental protection (ICPE) in Cadarache, previously operated by the CEA. In addition to reinforcing the technical requirements in terms of risk prevention, this order requires a reduction in authorised releases into the environment. Regarding the Fontenay-aux-Roses site, the prefect of the Hauts-de-Seine department requested a commitment to carrying out impact and danger studies in September 2005.

FOCUS

The IRSN's regulated facilities and activities

Activities subject to the environment code
Facilities classified for environmental prevention (ICPE)
- subject to authorisation: 10, nine of which are covered by sections 1700 (use or storage of radioactive substances).
- subject to declaration: 15, four of which are covered by sections 1,700

Nuclear activities subject to the public health code
Number of authorisations delivered by the DGSNR: 15

Employees exposed to ionising radiation
- Category A: 110 (24 women, 86 men)
- Category B: 860 (336 women, 524 men)

IRSN communication

The IRSN's action in this area can be broken down into two areas: external communication, aimed at the public, with respect to which the Institute is focusing on a policy of explaining what it does and describing its skills, and in-house communication aimed at staff with the intention of nurturing common values.

External communication

The IRSN's external communication policy contributes to the Institute's reputation. It also involves raising awareness about its policy of openness with society and its viewpoint as an independent expert.

The circulation of scientific information nurtures and strengthens the image of the Institute

As the main vector for circulating information from the IRSN, the Internet is a key contributor to widening the Institute's reputation. Different theme-based websites created by the Institute can be consulted on its portal, **www.irsn.org**. The restructuring of these websites continued in 2005, mainly with a view to making them more ergonomic.

Moreover, the IRSN continued to publish for its diverse readership in 2005, and this included the annual report offering a global overview of its activities. Published in French (5,000 copies), English (1,500 copies) and in a bilingual multimedia version (7,500 mini-CDs), this report can be consulted online via the Institute's portal.

The Institute has also updated its presentation document, 10,750 copies of which were circulated in French and 11,400 copies in English.

The IRSN published several leaflets circulated at professional trade fairs:

- *Face à un accident* (When an accident happens, 1500 copies), *Prestations dans le domaine non nucléaire* (Non-nuclear services, 1700 copies) and *La radioprotection* (Radiological protection, 2400 copies) were circulated at the Pollutec trade fair.
- The following leaflets were circulated at the Medec trade fair: *Exposition médicale aux rayonnements ionisants* (Medical exposure to ionising radiation, 8,400 copies), *Rayonnements ionisants et santé* (Ionising radiation and health, 6,000 copies) and *Assister les équipes médicales* (Supporting medical teams, 4,500 copies).

Theme-based websites accessible from the main IRSN website.

Reinforcing visual identity

In 2005, the IRSN changed its visual identity by developing a collection aimed at making its books immediately recognisable to the public.

In-house communication

This revolves around three areas:

- in-house information;
- awareness and dialogue;
- building a common identity.

In-house information

The in-house information system for IRSN staff was finalised in 2005. This is based on four tools:

- the in-house magazine *Repères*;
- in-house news flashes;
- information points at the units;
- the intranet.

A *Repères* readership survey carried out in 2005 confirmed the Institute employees' interest in this publication. The intranet was updated in 2005 to boost the number of connections by putting a series of practical new services online. This website is helping to improve the efficiency of the Institute through better comprehension of its different activities.

Awareness and dialogue

The IRSN management seminar and breakfast meetings organised in 2005 were an opportunity for IRSN employees to dialogue with their Director General and to fully understand the policies adopted by the Institute. Following these events, meetings were organised between the communications division and staff to present the Institute's initiatives in this area.

Examples of theme-based collections edited by the IRSN.

Building a common identity

Several initiatives were carried out in 2005 to promote the building of an identity shared by IRSN employees from their arrival. The human resources and communications divisions offer new arrivals a welcome package, show a film presenting the Institute and propose seminars.

The personnel of the Institute is also invited to in-house or external corporate bonding events such as the *Fête de la Science* (Science Festival).

The *Fête de la Science* scientific festival.

[INTERVIEW]

Marie-Pierre BIGOT,
IRSN Communications Director

> How does the IRSN see its role in terms of external communication?

Through its communication and information initiatives, the Institute is aiming to boost the French nation's level of confidence (general public, professional community and the press) in the institutional expert assessment system for personal and environmental protection from risks related to the use of ionising radiation. It can thus raise public awareness and enhance recognition by these sections of society of its status as a public authority expert in nuclear and radiological risk.

> Which challenges are met by the Institute's in-house communication policy?

The IRSN is still a very young organisation that needs to consolidate its identity and culture. The diverse nature of its personnel, their profiles, cultures and responsibilities is one of the Institute's key assets. The idea behind the in-house communication policy is to make this diversity a power element. In this respect, compliance with the charter for using the IRSN logo and the communication charter are contributing to the gradual consolidation of the Institute's identity and to its growing institutional and media presence.

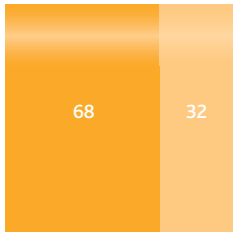
Human resources serving development at the IRSN

The IRSN's human resources policy offers a central role to the development of skills. The key events in this policy in 2005 were the performance of major initiatives in different areas such as training, employee protection or the corporate savings scheme, thus demonstrating the dynamic policy adopted by the Institute in terms of human resources and social relationships.

Fully-fledged IRSN staff

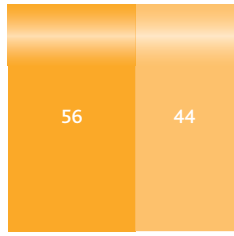
Now that the period of CEA staff secondment to the Institute is over (28 February 2005), the workforce is now composed exclusively of staff having signed an IRSN work contract. The IRSN therefore had 1,574 employees on permanent work contracts at 31 December 2005, including staff seconded to the DGSNR. The staff employed at the Institute's units represented 1,488.5 full-time equivalent positions for a target workforce of 1,524 full-time positions. Managerial staff makes up 68% of this workforce, with the remaining 32% in non-managerial staff. 56% of the workforce is composed of men and 44% of women.

Breakdown by socio-professional categories



Ingeneers, researchers and managerial staff **68%** *(68% in 2004)*
Non-managerial staff **32%** *(32% in 2004)*

Breakdown by gender



Men **56%** *(55% in 2004)*
Women**44 %** *(45% in 2004)*

2005: the finalisation of a host of debates and initiatives

The management of human resources at the IRSN is part of the Institute's global policy. Accordingly, a host of initiatives started the previous year were consolidated in 2005:

Expert Channel. The IRSN wanted to offer its employees new motivating career prospects notably through the creation of Expert functions. The missions of the employees involved should significantly contribute to accomplishing the objectives set out in the Institute's scientific and technical policy and its recognition within the international scientific community. Some 20 employees were thus appointed to expert or senior expert functions during the first series of appointments carried out in 2005.

Management. In 2005, the IRSN launched Management Workshops as part of restating the central role played by unit managers in implementing the Institute's strategy and motivating teams. In

2006, one of the key aims of this work is to set up a training programme focusing on line management responsibilities and a management charter officially stating what is expected of managers.

Annual interviews. A new development interview system was implemented to give added drive to these interviews.

Mission costs. A new reimbursement regime for mission costs was implemented based on the principle of actual costs with an upper limit in 2005 to replace the former fixed cost system, a legacy from the CEA.

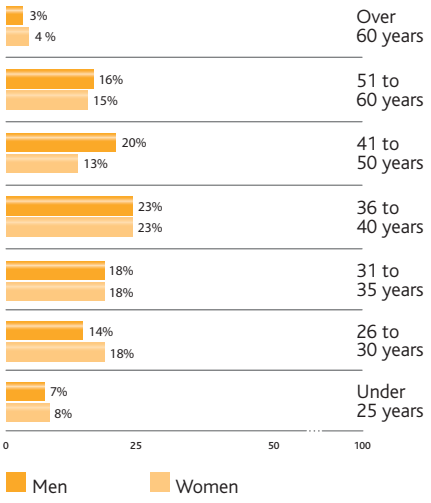
Clearer human resources management tools and procedures

Recruitment. The human resources division now systematically interviews the candidates preselected by the divisions to offer directors advice and a more comprehensive overview to help them in their decision-making process. This recruitment process was used for the 122 employees recruited by the Institute in 2005.

Mobility. Extending its scope in the scientific community by developing its relationships with French and international research bodies is a key objective for the IRSN. In 2005, some employees from the Institute thus joined outside bodies to continue on their career path.

Recruitment interview between the human resources division and a candidate.

Age pyramid



Social protection, payroll, elections, savings scheme: a dynamic social policy

The IRSN's social structure and corporate agreements offer a high level of protection for employees.

Social protection for employees. The health insurance option adopted in 2004 in agreement with the unions allows IRSN employees to benefit from comprehensive coverage of healthcare fees while paying lower health insurance contributions.

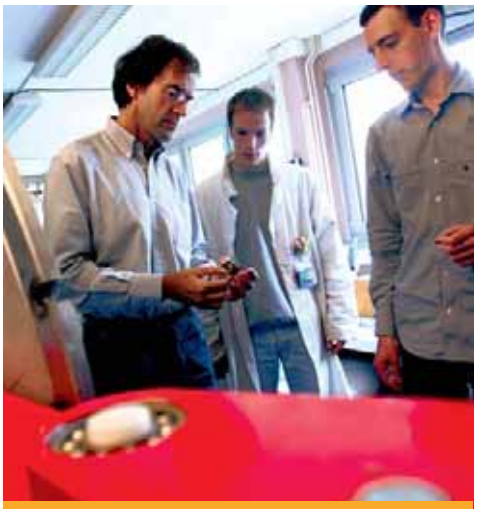
Payroll. In 2005, payroll negotiations did not reach an agreement and took place against a backdrop of considerable opposition by employees to the measures proposed by the management with respect to the 3% payroll scale set at the Institute. Similarly, negotiations also focused on setting up a managerial staff remuneration system adapted to the IRSN, and a new agreement to replace the previous CEA legacy agreement was signed by two union organisations. However, this new system could not be applied given the oppositions from the three unions which did not sign the agreement. A convention was also to drafted into an agreement allowing the Institute to dispense training in the fields of safety and radiological protection through its employees.

Elections. The bodies of the IRSN's works council and employee representatives were renewed for two years in June 2005 and about 40 meetings were held

over the year. With a budget of €1.15 million for social and cultural activities, the works council was directly responsible for all of its missions.

Employee savings scheme. By continuing to open employee savings schemes in 2005, the number of IRSN participating employees had reached nearly 30% at the end of the year. The Institute also developed its *1% logement* (accommodation aid) policy and chose two partner collecting bodies to allocate rented accommodation or property loans to employees. Finally, a direct loans system for personnel enabled about 15 employees to receive financial aid to purchase property or a vehicle in 2005.

Works council elections.



An increasing focus on training students through research.

Encouraging young people: a rise in the number of thesis students

The rise in the number of doctorate students preparing their thesis at IRSN laboratories (66 at 31 December 2005 as against 58 the previous year) is part of the Institute's policy to develop training through research. At 15, the number of young post-doctorate researchers at the IRSN remained stable in 2005. Moreover, out of 118 university student trainees at the IRSN, 77 were at the end of long-term scientific studies (French engineering school diplomas or the second year of a French masters' degree). Finally, the IRSN welcomed 16 apprentices in 2005, mostly as part of technical training at university level.

Professional training: increased efforts

In 2005, IRSN training expenditure stood at about 4.5% of payroll corresponding to an estimated 42,000 hours with 2,100 employees participating. The cost of teaching by training bodies thus rose to about €1.33 million. Two key initiatives from 2005:

- induction courses for new recruits allowing them to take stock of the IRSN's missions and objectives and to dialogue with employees from other units – 83 new employees took part in this in 2005;
- a training operation launched mid-year focusing on public speaking and aimed at the Institute's managers.

Breakdown by domain of training hours carried out in 2005

- Economy, management **2.11%** *(2% in 2004)*
- Quality **3.59%** *(9% in 2004)*
- Information Technology **9.25%** *(13% in 2004)*
- Relations, communication, management **12.21%** *(5% in 2004)*
- Safety, prevention **14.59%** *(10% in 2004)*
- Foreign languages **17.94 %** *(18% in 2004)*
- Technical sciences **40.31%** *(43% in 2004)*

[3]
IRSN ACTIVITIES

Programmes to achieve its missions

To optimise its performance in accomplishing its missions, the IRSN has organised its activities into 31 thematic programmes, some of which cover a number of missions. The activities connected with these programmes may therefore feature in several missions. An overall view of each programme can be obtained by referring to the table of contents at the end of this document.

RESEARCH AND EXPERTISE IN THE FIELD OF NUCLEAR RISKS

Human and organisational reliability

PAGES 51 108

This programme encompasses all IRSN's actions concerning human reliability and the analysis of organisations in the context of nuclear installations or other situations involving exposure to ionising radiation.

It thus responds to increasing demands by safety and radiological protection authorities and provides for changes connected with large-scale renewal of operating teams and the evolution of skills, especially as regards technologies.

Safety analysis of PWRs and other reactors in operation

PAGES 100 to 105

The IRSN ensures the follow-up of power reactors and experimental reactors in operation, in support of the safety authorities. The IRSN examines safety data and files submitted by reactor operators in accordance with regulations. It identifies and prioritises safety problems and analyses feedback. On the basis of this follow-up, notices or reports are drawn up in answer to questions from the safety authority.

Support for the safety analysis of reactors in operation

PAGES 50 51 106 107

The IRSN conducts R&D studies and actions regarding the safety of existing and future installations. Its activities can be divided into three fields: the development of probabilistic safety analyses, the carrying out of studies in support of analyses, and the acquisition and development of software and related R&D.

Ageing of pressurised water reactors (PWR)

PAGES 51 52 108

The ageing of nuclear power plants results in the degradation in components, and this has to be prevented, monitored and counteracted so that the installation can continue to operate in satisfactory safety conditions. The research and safety analyses conducted by the IRSN cover the various aspects of the problem (ageing of components, study of the behaviour of containments as they get older, and non-destructive tests).

In this field, the Institute ensures that its appraisals remain independent by carrying out its own work which is complementary to that performed by the operator.

Fuel and its management in normal and accident operating conditions

PAGES 52 to 54 109

For economic reasons, EDF wishes to extend the useful life of fuels and is turning to new materials. For these new operating conditions, the IRSN's work involves studies and research regarding the relevance of current safety criteria or the definition of new criteria, assessing the corresponding safety margins and improving knowledge.

Future reactors and innovative projects

PAGE 110

The purpose of this programme is to enable the Institute to identify and assess the safety problems of projects that are being considered to replace the current generation of nuclear power reactors. The programme concerns generation IV reactors, which are intended to achieve improvements in safety, reductions in waste and resistance to proliferation and malicious acts. In its early stages, this programme relies on close contacts with the designers and R&D organisations involved.

Severe reactor accidents

PAGES 56 to 59 109 to 111

The IRSN studies and research on pressurised water reactor core meltdown accidents (severe accidents) aim to achieve an adequate understanding of the phenomena in order to assess the risks associated with such accidents and the procedures adopted by operators to deal with them. The goal is to improve prevention of these accidents, to study the resources required to limit their consequences and to prepare the IRSN for crisis management in case of an accident.

Safety of plants, transport and dismantling

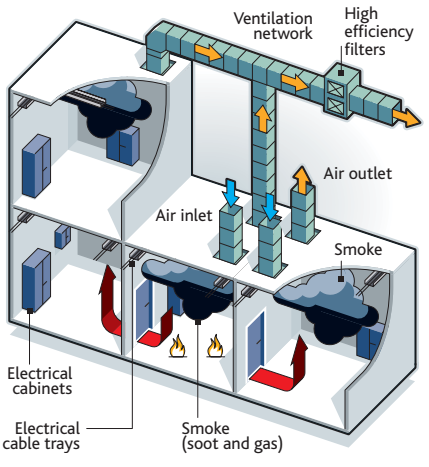
PAGES 60 to 62 111 to114 138 139

Nuclear installations upstream and downstream of the fuel cycle, and the transport of nuclear and radioactive materials, pose specific risks requiring a great deal of work in providing technical support for the relevant authorities and conducting studies and research, especially as regards the risk of criticality. This programme also concerns the safety of installations during dismantling and must specify any possible means of improving the safety of these operations, especially as EDF has decided to step up its dismantling programme.

Fire, explosion and dispersion

PAGES 65 to 68 117 137 141

This programme covers the IRSN's activities in the field of the control of risks associated with fire, explosion and air dispersion of radioactive or toxic contaminants within nuclear failities and in the environment. The aim of the studies, research and expert assessments under this programme is to contribute to improving the level of safety of installations and thereby provide better protection for the public, workers and the environment.



NUCLEAR DEFENCE EXPERTISE

Safety of defence-related installations, systems and transport

PAGE 150

The IRSN provides safety authorities with technical support for the safety assessment of military nuclear systems, secret basic nuclear installations and defence-related transport systems. Its activities are focused on the expert assessment of safety documents, the analysis of operating experience, the assessment of internal emergency plans and on crisis preparation.

Protection and control of nuclear and sensitive materials

PAGES 154 to 158

The IRSN's activities concern the assessment of the level of protection of nuclear materials against the risk of theft or hijacking for malicious purposes and compliance with France's international undertakings regarding the utilisation of materials which could be used to manufacture nuclear or chemical weapons.

In this context, the Institute provides public authorities with direct technical co-operation (national inspections, assistance with international inspections, operational missions) and gives technical support to the administrative authorities (expert assessment of dossiers, contribution to the drawing up of doctrines and regulations).

Protection against malicious acts

PAGES 159 to 161

This programme is intended to take malicious acts into consideration in the design and operation of nuclear installations. It also addresses the assessment of potential consequences of any malicious acts against transport containers for nuclear or radioactive materials.

PROTECTION OF MAN AND THE ENVIRONMENT AGAINST IONISING RADIATION

Environmental monitoring

PAGES 72 91 92 119 120 134 138

The purpose of this programme is to be aware, at all times, of the levels of radioactivity to which the population is exposed, to determine their origin and to ensure the early detection of any abnormal increase in ambient radiation fields in the various environments.

Radioactive waste management safety

PAGES 62 to 65 114 to 116 139

The aim of activities in this field is to assess the risks associated with radioactive waste and, if necessary, to identify possible means of improving their management with regard to safety and radiological protection. The actions carried out under this programme concern:

- the understanding of unused materials and substances, waste and packages;
- the storage and disposal of radioactive waste regardless of its origin, activity level and the radionuclides concerned;
- the management of spent sources;
- the contaminated sites.

These activities include the assessment of operators' dossiers, the drawing up of technical doctrines, as well as studies and research conducted in order to understand events that might affect the safety of disposal facilities.

Chronic risks

PAGES 72 to 75

This programme contributes to assessment of the effects of chronic exposure to low-level radioactive contaminants. Although the risks are low for a given individual, they apply to very large human populations and ecosystems, and this could lead to significant consequences on the global level.

Enhancing their assessment may therefore offer advantages for the purposes of health or environmental management.

Radioecology

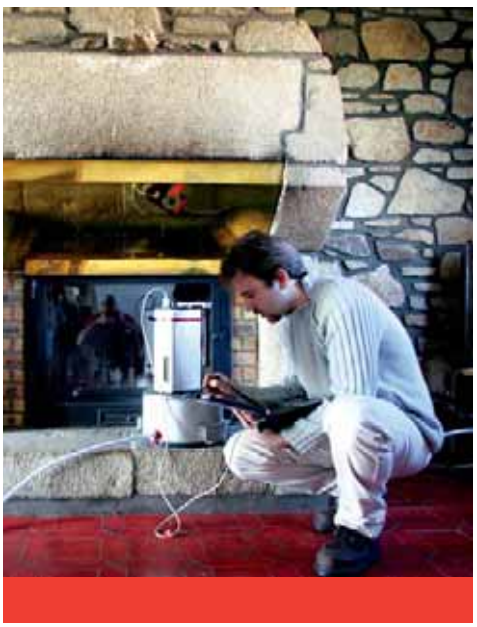
PAGES 69 to 71 118 140 141

The research and studies conducted at the IRSN contribute to the development of knowledge and understanding of the origin and the future of radionuclides released or already existing in the environment. The aim is to assess their radiological impact in normal operating, incident and accident conditions. In operational terms, this entails making crisis management plans in case of a radioactive release, with the use of decision tools for the prediction of releases and their evolution, and the rehabilitation of the environment near, and far from, the accident site.

Radon

PAGES 75 76 120 121 134 141

For more than 20 years, the IRSN has been studying radon in all its aspects: formation and migration in the soil, exhalation and then dispersion in the atmosphere, metrology mapping, accumulation in buildings, health risks, reduction of concentrations, etc. Having acquired knowledge and experience that are unmatched in France, the Institute is able to provide support for public authorities and parties responsible for implementing a radon risk management.



Radiological protection of workers

PAGES 76 77 122 123 135

This programme includes the IRSN's actions regarding internal and external exposure of workers inside, or outside, nuclear installations and at work stations involving exposure to ionising radiation. Its goal is to identify the most critical situations and to analyse ways of reducing exposure.

Radiological protection in the medical field

PAGES 79 80 123 124 143 144

Medical exposure is the main source of exposure to ionising radiation of artificial origin for the general population. This exposure can constitute risks for patients and practitioners. This programme entails three main topics:

- study on delayed complications in patients treated by radiotherapy;
- monitoring of medical exposures;
- medical expert assessment.

Exposure assessment and protection equipment

PAGES 77 à 79 92 93 136 142 143

This programme aims to improve understanding of the exposure of individuals in normal situations and to carry out dosimetric expert assessments in complex situations in several areas:

- expert assessment of radiological protection and epidemiology of populations concerned;
- dosimetry, routine measuring equipment;
- dosimetry, measuring equipment under development.

Radiological protection policy

PAGES 86 87

The radiological protection policy is drawn up internationally by various scientific, technical and regulatory organisations (ICRP, NEA, IAEA, Euratom, etc.).

The IRSN's action as regards these organisations concerns policy changes, the adoption of new topics for study and the development of dialogue with all French parties concerned by radiological protection.

HAZARDS AND CRISIS SITUATIONS

Naturally-occurring hazards

PAGES 68 69 117 118

The actions carried out by the IRSN are aimed at assessing the safety of installations with respect to natural hazards such as earthquakes and floods and at identifying any possible improvements. This programme covers:

- the risks of flooding and severe drops in water levels that could affect nuclear installations;
- the development, optimisation and validation of methods and tools to assess seismic hazards.

Management of emergency situations

PAGES 126 to 130

The IRSN's facilities (technical crisis centre, mobile facilities, etc.) are maintained in an operational state and are constantly improved so that the Institute can provide assistance to public authorities in the event of an accident or post-accident situation in France. The Institute draws up contingency plans and takes part in crisis exercises. In this way, its teams are trained in interaction with other players in the crisis, exercises are organised on a national level and national or international contingency plans are drawn up. Feedback in this field is a key factor in achieving progress.

This programme is made up of two parts:

- studies and developments, crisis exercises;
- maintaining the technical crisis centre and its mobile facilities in an operational state.

Management of post-accident situations

PAGES 82 83 130 131

The post-accident management of a nuclear or radiological crisis may involve a large number of players called upon, over the course of time, to manage many interdependent tasks: radiological protection and the follow-up of the health of populations, rehabilitation of areas affected, redeployment of industrial and agricultural activities and compensation for victims, etc.

The aim of this programme is to set up an organisation, methods and a range of technical tools, along with a network of external contacts, to enable all the stakeholders to carry out their missions effectively.

Irradiation and contamination accidents

PAGES 80 to 82

Following an accidental exposure to ionising radiation, medical teams must be able to assess the injuries suffered by the irradiated individual in the shortest possible time in order to establish a reliable diagnosis and implement a suitable treatment protocol. As a provider of technical support to hospitals, the IRSN's objective is to improve diagnosis by making optimal use of the interface between dosimetry, biological research and medical applications.

Radiological protection response and assistance

PAGES 121 122 136 137 144 145

This programme covers:

- activities involving inspections, tests and expert assessments of the effectiveness of ventilation and filtration systems in nuclear installations;
- assistance and response in the field of operational radiological protection in order to characterise the radiological state of premises and sites and to assist with the management of abnormal situations;
- monitoring activities in accordance with the decree regarding worker protection against the hazards of ionising radiation.

These activities are performed in accordance with agreements with the relevant public authorities.

TRAINING AND DISSEMINATION

Contribution to public information and transparency

PAGES 94 to 97

As part of its missions, the Institute helps to provide information to the public and public authorities about nuclear safety and the protection of persons and the environment. It publishes the scientific results of its study and research programmes.
The IRSN is also seeking to make its expertise responsive to the expectations of society. The Institute has undertaken a number of pilot projects to achieve greater transparency in the field of nuclear and radiological risk management. These projects, pursued in conjunction with social players, provide the basis for access to the IRSN's analyses and studies for Local Information Commissions. Furthermore, the IRSN is working on steps to involve stakeholders in pluralistic expert groups with the aim of considering the technical issues of complex and controversial topics.

Training and education through research

PAGES 88 to 90

The IRSN's knowledge base is formalised, enhanced and taught through its education activities. The Institute sets up external and internal training courses, participates in external teaching and provides support for theses and work experience periods. Furthermore, the IRSN's policy of scientific and technical excellence aims to achieve the highest possible level of scientific and technical merit in all its research and study activities, and recognition of that excellence.

International assistance, support for programmes and agreements

PAGES 84 to 86 125 146 147

The Institute's international activities include:
- bilateral relations with its foreign counterparts;
- relations with international organisations;
- special involvement in relations with European institutions;
- support for foreign safety authorities;
- contributions to the international activities of the French safety authorities.

INVESTMENTS

Upgrading of the CABRI installation

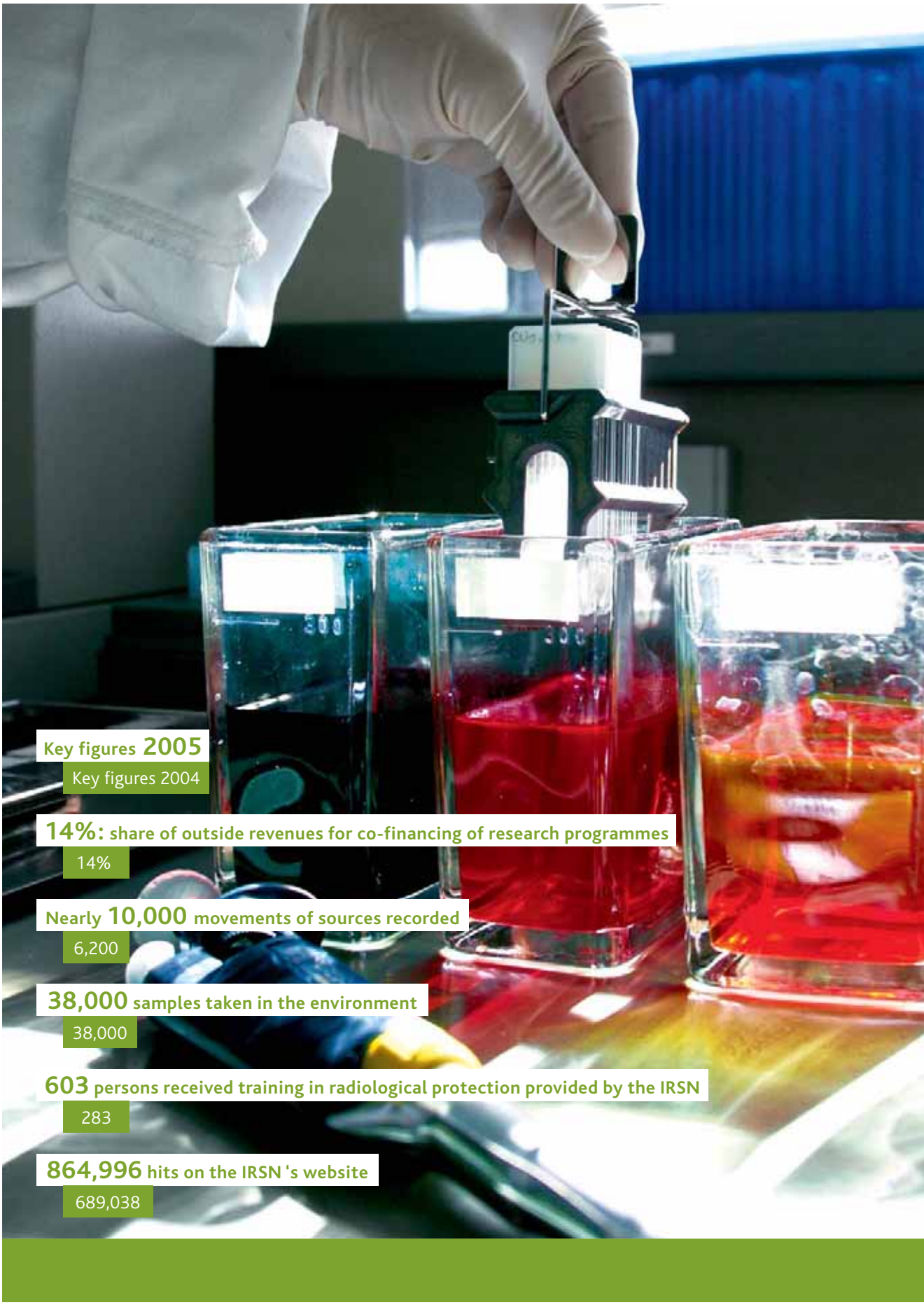
PAGES 55 56

The upgrading of the CABRI installation involves improving the earthquake resistance of the buildings and equipment, renovating the ventilation system and installing a pressurised water loop to replace the sodium loop. This installation will be used, for the international CIP programme, to study the behaviour of the fuel during a reactivity accident in conditions representative of the core of a pressurised water reactor.

AMANDE

PAGE 79

This new installation produces monoenergetic neutron beams of metrological standard needed for the study and characterisation of neutron detectors used for radiological protection. The AMANDE project adds to the reference installations already operated by the IRSN and provides it with references comparable with those available at major international metrology laboratories.



Key figures **2005**

Key figures 2004

14%: share of outside revenues for co-financing of research programmes

14%

Nearly **10,000** **movements of sources recorded**

6,200

38,000 **samples taken in the environment**

38,000

603 **persons received training in radiological protection provided by the IRSN**

283

864,996 **hits on the IRSN 's website**

689,038

RESEARCH AND PUBLIC SERVICE MISSIONS

The research programmes conducted by the IRSN have several objectives: to provide the skills required for suitable expertise in the Institute's fields of activity and to prepare the necessary changes regarding the control of risks related to nuclear activities. The IRSN is also responsible for public service missions such as radiological protection monitoring and contributing to public information and transparency.

Defining and implementing national and international research programmes

The research programmes developed by the IRSN are essentially applied research programmes, including work related to basic research. They aim to develop knowledge useful for expertise in the short, medium or long term. These research activities are conducted through national and international co-operation, by welcoming thesis students, developing programmes in partnership and setting up joint research units.

72 theses in progress
(63 in 2004)

24 post-doctorates
(16 in 2004)

42 holders of **senior doctorates** or authorised to supervise research
(37 in 2004)

350 communications at congresses
(349 in 2004)

31 current study and research **topics**
(31 in 2004)

25 ICPE under the environment code
(26 in 2004)

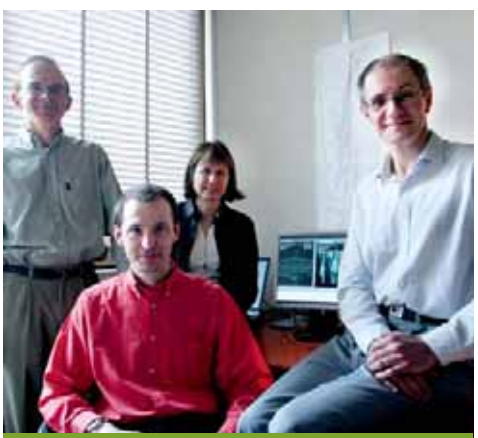
15 nuclear activities authorised in accordance with the public health code
(14 in 2004)

10 current **European projects** in radiological protection and safety
(8 in 2004)

21 foreign scientists hosted
(38 in 2004)

RESEARCH WORK SUPPORTING THE SAFETY ANALYSIS OF REACTORS IN OPERATION

The IRSN carries out research and development action regarding the safety of reactors in operation in order to develop means of assessing programmed systems and appraising the possibilities offered by the development of non-destructive test methods.



The IRSN's experts responsible for assessing programmed systems.

Assessment of programmed systems

It is becoming increasingly difficult to assess the software used in systems and command-control equipment owing to their increasing complexity. The IRSN is pursuing a sustained R&D effort to develop analysis tools and to encourage operators to improve, where applicable, the facilities and methods they use to perform their own verifications.

In 2005, this work was focused on assessing the cover provided by tests with the GATEL tool, the verification of the design rules for multi-task systems with the CHRONOSCOPE tool which was developed for a thesis, and the static analysis of source codes with the VALVIEWER tool.

Software for non-destructive tests

Working in co-operation with the CEA, the IRSN is developing non-destructive test simulation software packages. These are designed to ascertain the condition of materials and so make sure there are no defects liable to adversely affect the safety of the components concerned. The CIVA software for modelling ultrasonic and eddy current examinations enable the Institute to assess the performances of inspections conducted, independently of the operators concerned.

It can also be used to substantiate requests to operators to make improvements to inspections.

SIPA simulator

In 2005, the SIPA simulator *(see Focus opposite)* was used for:

- thermal-hydraulic studies, especially for the level 2 probabilistic safety analysis (PSA) of 900 MWe reactors;
- training in physics and reactor control;
- the preparation of three national crisis exercise scenarios.

RESEARCH ON PWR AGEING

The IRSN is working together with the CEA to carry out R&D regarding the mechanisms of degradation of equipment materials that are important for the safety of nuclear installations.

In 2005, the main research topics were: wear on mating parts, fatigue on pipes vibrating due to the effects of flow, thermal fatigue in zones where two fluids of different temperatures mix, and stress corrosion. The general purpose of this research is to obtain better knowledge of degradation conditions or kinetics which are still little known or unknown *(see also Focus*)*.

FOCUS p.52

RESEARCH WORK ON HUMAN AND ORGANISATIONAL RELIABILITY

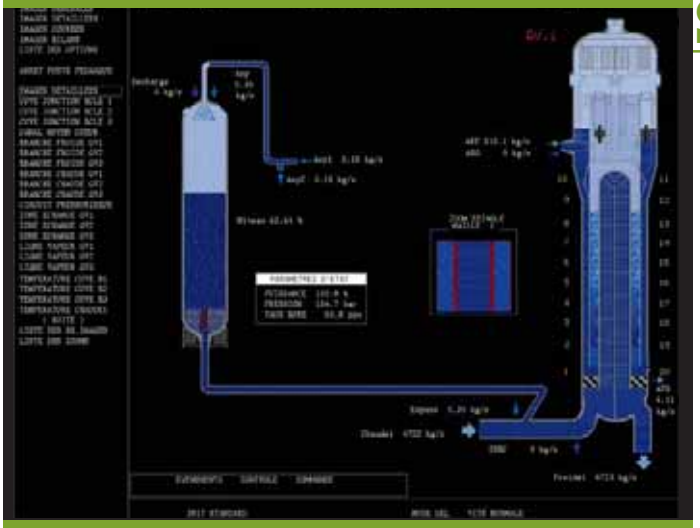
The IRSN carries out studies on the operation and assessment of organisations.

Assessment of organisations

In 2005, the IRSN carried out research on the integration of human factors in the design of installations. After preparatory work in conjunction with industrial partners, a study was conducted on maintenance subcontracting and safety management. This work was the subject of theses.

[FOCUS]

Renovation of the SIPA 2 simulator



Simulation of an accident scenario using SIPA.

After a year of thorough study, the SIPA simulator renovation project was drawn up in 2005. This simulator is used to simulate the behaviour of 900 MWe and 1,300 MWe reactors in accident situations.
The IRSN and Framatome signed a contract, in December 2005, to renovate their respective simulators together.
This contract defines the allocation of costs and the pulling of the competencies required to carry out the project.
The SIPA 2 simulator has been operating at the IRSN since 1992 and its renovation became necessary owing to the obsolescence of its computer hardware and increasing maintenance costs.
The project, which is to begin in 2006, includes the creation of new simulation configurations for the 900 MWe, 1,300 MWe and 1,450 MWe reactors by 2009. These configurations will be created jointly by the IRSN and Areva NP with the support of the Canadian manufacturing company, L3-COM-MAPPS, for the supply of computer hardware and software.
In addition to providing greater flexibility in use, the new simulator configurations will make it possible to simulate the behaviour of all EDF reactors including, eventually, EPR.

[FOCUS]

International seminar on the impact of ageing on reliability

Fifty experts took part in the seminar on the impact of ageing on reliability.

The IRSN, along with the Dutch Institute for Energy, organised a seminar on the practical applications of age-dependent reliability models and the analysis of data obtained through operating experience. The aim of this international meeting was to describe and exchange experiences regarding the practical application of time-related reliability models for components and systems. Probabilistic safety analyses (PSA) are indeed being used more and more to assess the safety of installations. However, the PSAs usually used do not include time-dependent reliability models for components and systems, and cannot assess the effects of maintenance on the reliability and availability of systems that are important for safety.

The topics considered during this seminar included:

- management of ageing and treatment of ageing effects in PWRs;
- modelling of the ageing of components;
- operating experience;
- accelerated ageing tests.

Fifty experts from various countries and sectors (research organisations, safety organisations, industrial groups and consultants) took part in this seminar during which 18 papers were presented, including two by the IRSN.

For further information:

www.energyrisks.jrc.nl/APSA/Workshops.htm
http://seminaire_apsa2005.irsn.org/index.php

Analysis of expert assessment practices

In 2005, the IRSN began research, in co-operation with the *Ecole Nationale Supérieure des Mines de Paris* (engineering school), to consolidate the available knowledge on expert assessment practices implemented in the field of human and organisational factors.

FUEL AND ITS MANAGEMENT IN NORMAL AND ACCIDENT OPERATING CONDITIONS

The study of fuel behaviour, one of the research projects conducted by the IRSN, mainly concerns the accidents of control rod ejection, loss of coolant and dewatering of spent fuel pits.

In 2005, the IRSN carried out a new examination of the safety criteria to be applied to fuel in normal operation, incident-related situations and accident situations. This re-examination became necessary owing to recent changes in:

- cladding and structural materials;
- operating conditions, especially the increase in fuel burnup fraction and fissile material enrichment;
- knowledge acquired, especially through R&D programmes, conducted by the IRSN or with its participation, on fuel in normal and accident operation.

This new examination will contribute to the input for the preparation of a safety standard for future fuel management systems. The conclusion of these studies will be presented to the Standing advisory group for nuclear reactors in 2007 or 2008.

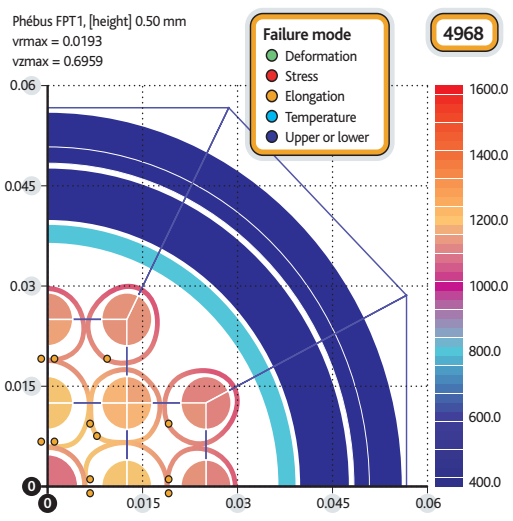
Control rod ejection accidents

As regards control rod ejection accidents in particular, the safety demonstration is currently based mainly on the results of the CABRI REP-Na tests, a summary of which is to be published in 2006.

In 2005, international co-operation for the new CABRI International Project (CABRI-CIP) which followed on from the CABRI REP-Na tests, led to a technical seminar and the meeting of the Technical advisory group of experts. This group undertook the preparation of the test matrix for tests to be carried out in the pressurised water loop and which will be the subject of detailed quantitative analyses. In the scope of this programme, the IRSN is examining the possibilities of using the Japanese NSRR reactor, operated by JAEA, to study the behaviour of the fission gases present in the irradiated fuel in case of rapid heating. A researcher from the IRSN has been seconded to the NSRR team.
Development of the SCANAIR software, used for the preparation and interpretation of the CABRI tests and for transposition to power reactor scale, has continued. This software models the behaviour of a fuel rod subjected to a sudden power change. The main development introduced in 2005 was a model to assess heat exchanges between a rod cladding and the coolant in the test conditions provided in the NSRR reactor. This development was used to enrich the validation base for the SCANAIR software.

Detailed modelling actions using recent methods to predict clad cracking have been jointly financed by EDF and Areva since 2005. They were used, in 2005, to defend a thesis on the modelling of crack propagation in a rod cladding during a rod ejection accident or a power ramp.

Loss of coolant accident (LOCA)



DRACCAR calculation of cladding deformation in the Phebus FPT1 test.

The IRSN is playing an active part in the definition and interpretation of tests in experimental programmes concerning the behaviour of irradiated fuel during a LOCA, which are being conducted in the USA (ANL), Japan (JAEA) and Norway (Halden).

The first two of these programmes entail out-of-pile tests on an irradiated fuel rod section extracted from a power reactor. The principle of these tests consists in submitting the rod section, initially featuring internal pressure, to a sudden temperature change representative of the calculated change for a fuel rod in a reactor. The aim is to study its behaviour during the main accident development phases: swelling and failure of the cladding, possible displacement of the fragmented fuel into the swollen regions of the cladding, high-temperature oxidation and hydridation of the cladding, and behaviour when wetted on reflooding. These integral type tests are completed by a set of mechanical tests conducted at low temperature on new pre-hydrated or irradiated cladding sections that have been submitted to high-temperature oxidation. These tests can be used to measure the residual mechanical characteristics of the cladding in the post-accident phase during which the rods may be subjected to various stresses (hydraulic, seismic, handling).
The tests in the 3rd programme concern a single rod. They are carried out in the Halden test reactor and their main objective is to characterise the displacements of irradiated fuel fragments inside the swollen regions which form during swelling of the cladding.
The IRSN has drawn up a summary of all the successful LOCA programmes conducted since 1973. In this way, the Institute has been able to identify gaps in available knowledge concerning the utilisation of fresh fuels with a high burnup rate. This work has also allowed the Institute to offer its French and international partners an R&D programme on LOCA focusing on those aspects.

[FOCUS]

Loss of coolant accident (LOCA)

The IRSN has started studying the definition of LOCA study guidelines which are to specify the following:

- the reference transient (large and/or small break) studied for the safety demonstration to justify the efficiency of the safety water injection system;
- the physical phenomena to be considered;
- the validity of the related safety criteria.

This action is being pursued in an international context in which all the participants, including US-NRC agreed to prepare a new approach based on the results of R&D programmes in which the IRSN has played a major part *(see Focus*)*.

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Development of the DRACCAR software has begun, with the aim of modelling the deformations that occur in dual rod assemblies in the event of a LOCA, taking into account the thermal and mechanical interactions between rods. As existing tools can only model a single "average" rod, this will offer improvements for the interpretation of the existing experimental base.
Transposition of the results to the reactor scale will allow better evaluation of the deformations occurring on the hottest rods during a LOCA. The goal is to be able to assess the efficiency of core cooling during the accident in the short and long terms.

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Spent fuel pit drainage accident

Fuel pit at the La Hague plant.

A R&D programme was started up at the IRSN in 2005 to study the consequences of a spent fuel pit drainage accident (a PWR spent fuel pit or a pit at the La Hague reprocessing plant). Accidental drainage of the water in which the stored assemblies are located would lead to a temperature increase, occurring all the more quickly as the fuel's residual power after irradiation in the reactor is high. This temperature increase, intensified by direct exposure of the fuel rods to air (as the cladding oxidation reaction is more exothermic by oxygen than by steam) could, in some cases, lead to cladding failures due to the internal pressure in the rods. These failures would then result in the release of fission products.

There remains a major uncertainty regarding the consequences of the oxidation of zircaloy claddings by air. The R&D programme comprises a first part for the study and development of models which could be used to calculate this type of accident. Another part concerns the performance and interpretation of tests with different effects with the aim of achieving better understanding of the mechanisms of zircaloy cladding oxidation and nitridation in the presence of air. A third part, the feasibility of which will be examined in 2007, concerns the performance of semi-integral tests on assembly mockups in order to obtain global information for the validation of the models used. *(see also Focus Risk of spent fuel pit drainage*)*

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Spent fuel pit dewatering accident

The Institute is conducting an R&D programme concerning accidents involving the dewatering of irradiated fuel assemblies during handling or in spent fuel pits *(see Focus left-hand page)*. In 2005, this work concerned the study of a fuel assembly dewatering accident during handling.

MODIFICATION WORK ON THE CABRI INSTALLATION

The modification work on the CABRI installation will make it possible to conduct tests in conditions that are representative of those in a pressurised water reactor. This work entails, in particular, the setting up of a pressurised water loop to replace the sodium loop previously used to study the fuel of fast neutron reactors and, then, water reactors (previous REP-Na programme).

The research programmes conducted in the CEA's CABRI research reactor (Cadarache, Bouches-du-Rhône, France) on the behaviour of fuels highly irradiated during a sudden power change will make it possible to collect experimental data on the effects of an increase in burnup fraction on these fuels. In addition to the work to install the water loop, the installation's safety will be upgraded. It is also planned to renew some items of equipment. In parallel, the IRSN is developing an instrumented test device to receive the irradiated fuel rod sections which will be tested. The international CABRI CIP programme will comprise some 10 tests as from 2009, at an average rate of three a year.

Work progress

In 2005, the vessel containing the essential components of the pressurised water loop (pressuriser, pump, relief tank, etc.) was installed and the first phase of the seismic upgrading work for the CABRI pool-type reactor vessel was conducted.

Progress in studies

The studies on the representativeness of the CABRI test device compared with the case of a

WHAT IS A SEVERE ACCIDENT?

A severe accident may be caused by a core water cooling fault, preventing the power produced by the reactor from being removed, even after shutdown of the chain reaction (residual power). Over a period of between one and several hours, following multiple human or equipment failures, degradation of the fuel and then core meltdown may occur. Complex phenomena would then take place and their impact would depend on the accident's initial conditions and operators' actions.
In the case of existing PWRs, the accident would comprise four main phases:

- Due to the residual power, the fuels in the reactor core would lose their integrity, hydrogen would be released due to oxidation of the claddings by steam, and fission products would be released into the containment.
- If water was not injected into the reactor vessel, the core would melt and the mass of molten material formed in this way (known as corium) would first attack and, then, perforate the vessel bottom head. In the specific case where the vessel is still pressuring and in case of failure, the ejection of corium into the containment could lead to direct heating of the atmosphere in the containment. Furthermore, in case of advanced degradation, a steam explosion could occur. The containment could also be subjected to the stress of an explosion of the hydrogen present (deflagration or detonation).
- Due to the effect of the heat released by the corium, the concrete base mat under the vessel could be damaged to the point of perforation. This damage would also have the consequence of releasing various gases which, along with the steam already created, would cause a gradual pressure increase in the containment.
- Some of the fission products (noble gases, iodine, caesium, etc.) could escape from the containment if it was damaged as a result of the stresses generated by the above-mentioned events or if the U5 emergency procedure was implemented (deliberate decompression with filtration with the aim of limiting the pressure in the containment to a magnitude in the vicinity of its design pressure).

An accident of this type on the current PWRs could thus lead to considerable radioactive releases into the environment.

[FOCUS]

ASTEC, backbone of the SARNET network

The ASTEC software team.

Jointly developed by the IRSN and its German counterpart, GRS, to simulate the whole of a severe accident in a PWR, the ASTEC software has a central role in the development of the SARNET network.
An initial summary of the assessment of the software's possibilities was drawn up in 2005. This work was carried out by 27 organisations by comparing calculations and results from experimental programmes with calculation results from accident scenarios for PWR and VVER reactors obtained with other software packages.
Some improvements in the modelling of the behaviour of fission products were based on a consensus of opinions from network specialists. These will be included in the software in 2006.
In addition, general specifications were drawn up in order to adapt the ASTEC physical models to other water reactors of the BWR, CANDU and VVER types. In this way, ASTEC should become the standard European software for the purpose of severe accidents.

PWR were completed in 2005 in co-operation with SERCO, a British engineering services firm in London. They demonstrate that the tests to be performed in the CABRI installation will be transposable to the case of a reactor.
The national and international partners in the CABRI CIP experimental programme met in 2005. The conditions for half the tests in the programme have now been defined.

RESEARCH WORK ON SEVERE ACCIDENTS* WITH CORE MELTDOWN IN A PWR

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The approach adopted for this programme is based on the definition of accident scenarios, the identification of physico-chemical phenomena, the conducting of experiments with separate effects for the development of elementary mathematical models, and the development of computing software including those models, and their qualification in more comprehensive experiments.

Deployment of the European SARNET network

The main purpose of this network is to optimise the co-ordination of the development of knowledge in the field of severe accidents by pooling experimental and modelling work. It was started up on 2 April 2004 in the context of the European Commission's 6th FPRD. Co-ordinated by the IRSN, it involves 49 organisations from 18 European countries engaged in research on the safety of nuclear reactors (safety organisations, universities, industrialists, etc.). In 2005, the deployment of the SARNET network was continued and its first international seminar on severe accidents in water reactors, entitled ERMSAR, was held from November 14 to 16 in Aix-en-Provence (France). This seminar was attended by more than 120 participants. It finished with a review and discussion session on the future directions and priorities to be assigned to SARNET. These conclusions will be used to define the next action plan for the network.

The feedback from the 27 organisations in the ASTEC software user network *(see Focus left-hand page)* was integrated in version V1.2, delivered in July 2005. In particular, it led to an improvement in the software's robustness. Some 20 circles of experts from the network have continued their analysis in fields of interest in terms of R&D, the interpretation of tests and the construction of models. A prioritisation method was drawn up and implemented in order to update the priorities defined in 2003 in the context of the EURSAFE project[3] on which the network was based when it was started up.

With the aim of optimising the integration of knowledge acquired through national and international programmes, the SARNET network established relationships with:

- the Russian ISTC organisation, in order to take part in the definition of research programmes regarding severe accidents in Russia;
- the SOURCE TERM programme *(see Focus opposite)*, whose test parameters are defined jointly and the first results of which are being interpreted by the network's circles of experts;
- the OECD's GAMA group, in the context of which an exercise to compare the results of computer codes on accident scenarios featuring reactor core degradation is being led by the IRSN.

Public information regarding the network is available on the **www.sar-net.org** website that has been in service since early 2005.

ERMSAR 2005 IN FIGURES

Participation:
- 120 specialists;
- 50 organisations, including 12 by invitation (4 electricity utilities, 4 safety authorities, 3 research organisations and 1 university);
- 19 countries including 3 outside Europe (Canada, South Korea, Russia).

(3) European project of the 5th FPRD which aims to prioritise the needs to acquire new knowledge in the field of severe accidents.

[FOCUS]

Start-up of the SOURCE TERM programme

The BECARRE installation.

The IRSN started up a new research programme called SOURCE TERM in 2005. The objective of this five-year programme is to reduce the uncertainties inherent in the assessment of releases of radioactive products into the environment in the case of a core meltdown accident in a water reactor. Conducted in France in partnership with the CEA and EDF, this co-operative research programme has received international backing and is to be jointly financed by the European Commission, the Paul Scherrer Institute in Villigen (Switzerland), the AECL research organisation in Canada, and US-NRC (USA).

This experimental programme covers four fields of investigation:
- the chemistry of iodine in the reactor primary cooling system (CHIP tests) and in the containment (EPICUR tests);
- the effect of air on the degradation of fuel elements, especially on the oxidisation of claddings (MOZART tests)
- the release of ruthenium, and its chemical behaviour in the containment;
- the effect of the degradation of boron carbide control rods on the development of the accident and on the corresponding effect on radioactive releases (BECARRE tests);
- releases of fission products from irradiated fuels (UO_2 and MOX).

The year 2005 was marked by the inauguration of the EPICUR installation in May, followed by the performance of the first tests in that installation and, finally, the conducting of MOZART and BECARRE tests.

[FOCUS]

PHEBUS programme: first results of the FPT3 test

Storage of PHEBUS samples.

In 2005, non-destructive measurements (radiography, tomography, γ spectrometry) were performed on the test device and aerosols and vapours sampled during the PHEBUS FPT3 test (conducted in 2004) were analysed.
Measurements of γ emission from 320 aerosol samples collected (sampled by filtering or sedimentary deposits) will be used in the various test phases to quantify the releases and deposits of fission product aerosols and vapours (including organic iodine and molecular iodine) in the systems and the tank simulating the primary cooling system of a PWR containment.
The profiles for γ emission, x-ray densitometry and γ and x-ray tomography for the test device confirm that the objective of moderate degradation of the fuel (limited melting of the fuel) was achieved. The first interpretation calculations, performed using the ICARE 2 software, successfully reproduced the thermal state of the fuel assembly during the test but underestimated its final state of degradation.
This could be due to inadequate modelling of the effect of the control rod boron carbide.

Studies and research conducted on severe accidents by the IRSN in 2005

Core degradation and behaviour of the corium in tank

This accident phase is being studied at the IRSN using the ICARE/CATHARE software developed by the Institute. In the context of the level 2 PSA that it is developing for 900 MWe reactors, calculations of new accident sequences were performed using version 1 of the software to study the breaks caused in the primary cooling system, especially on the steam generator tubes in the case of core meltdown under pressure.
Major advances in development were achieved to prepare version 2 of the software. This version will be delivered in 2006 to perform calculations for the reflooding of a degraded core in the context of the level 2 PSA conducted by the IRSN for 1,300 MWe reactors. The new version will make it possible to process thermal-hydraulics and movements of materials in the core in two dimensions. Other improvements were achieved in 2005 on the modelling of radiation phenomena in the core and on the oxidation of rod claddings in air.
On 17 and 18 November 2005, the IRSN organised the second international seminar of the ICARE/CATHARE software users' club in Aix-en-Provence (France). This seminar attracted some 30 participants, including 15 from foreign organisations. On the basis of all the accounts given, a complete overview of the advantages and limitations of the current version V1 was drawn up and the enhancements expected of V2 were identified.

Behaviour of fission products

In recent years, the study of the behaviour of fission products at the IRSN has been closely linked to the development of the international PHEBUS-FP programme. In 2005, processing of the first results of the last FPT-3 test carried out in 2004 was started *(see Focus opposite)*.
Research on the behaviour of fission products during a core meltdown accident will be continued in the context of the SOURCE TERM programme *(see Focus*)*.

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Containment strength

The main aim of studies in this field is to fully understand the risk of early and direct releases of radioactive products into the environment.

As regards hydrogen explosions, the development of the TONUS software database was completed in 2005. Experimental actions conducted in collaboration with the CNRS in Orléans (France), were carried out in order to refine the flame acceleration criteria and improve the prediction of the triggering of detonations.
The last spraying tests in the experimental TOSQAN programme were performed in 2005 and the interpretation of their results was started. These tests will be used to qualify predictions by the TONUS-CFD and ASTEC/CPA software regarding the distribution of hydrogen and changes in pressure in the containment. Two of them are being used for reference for an international exercise to compare software packages. An experimental programme on direct heating of the containment atmosphere, conducted in collaboration with the German FzK research centre in its DISCO installation, was successfully completed. The results will be used to improve the ASTEC/RUPUICUV software models and to enhance the assessment of the consequences of corium ejection under pressure into the containment.
As regards the risks of steam explosion *(see Focus below)*, version V3.5 of the MC3D software was delivered. It reflects feedback from the software's users and the most recent assessment works.

Summary of the RECI programme

[FOCUS]

The RECI (RECombiner and Iodine) programme was completed in 2005. The aim of this IRSN programme was to improve the knowledge available on the behaviour of fission products in a nuclear reactor containment in case of a severe accident.

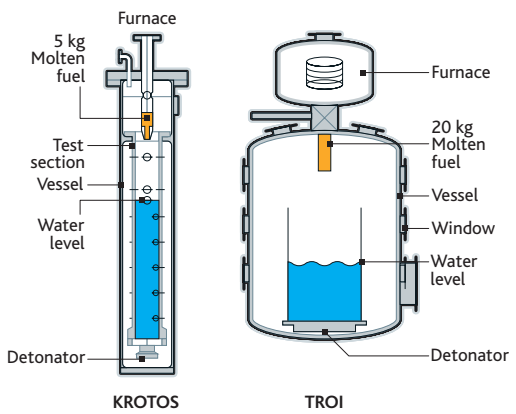
The RECI experiments revealed physicochemical reactions generating volatile iodine by dissociation of solid metal iodides. These reactions may take place when these iodides are heated inside hydrogen recombiners when in operation.

Owing to the very small scale of the analytical experiments in the RECI programme, the results obtained for caesium and cadmium iodides cannot be directly extrapolated to the case of a reactor.

However, they can be used to scale an experimental facility that is more representative of actual situations and already make it possible to obtain a first estimate (using the IODE module of the ASTEC software) of the impact of hydrogen catalytic recombiners on iodine releases.

Review and prospects of the SERENA programme of OECD-NEA

[FOCUS]



KROTOS and TROI: two complementary installations for the study of steam explosions.

The leading international experts in the field of steam explosions joined the SERENA programme, conducted from 2001 to 2005, to assess current understanding of the phenomena and the computing possibilities provided by digital tools. The IRSN participated in this programme with its MC3D software, in partnership with the CEA.
There are real differences of appreciation as regards the very nature of the phenomenon. Furthermore, the scattering of calculation results obtained using various software packages show that substantial efforts are still required in order to achieve a better understanding of the explosion phase.
The CEA and the IRSN, in co-operation with the Korean KAERI and KINS institutes, proposed a second study phase based on the KROTOS (CEA) and TROI (KAERI) experimental programmes in order to better define the consequences of a steam explosion for fuels and situations representative of reactor cases.

SAFETY OF LABORATORIES, PLANTS, TRANSPORT AND DISMANTLING

Study and research work in this field concerns, in particular, the risks of criticality and dispersion of radioactive materials outside containments.

Criticality studies, research and developments

The studies conducted to assess the criticality risk rely on computing software packages which use nuclear data libraries (cross sections). These software packages must be able to solve neutronics problems which differ greatly from one to the other owing to the diversity of fissile media encountered and the geometry of their containing equipment.

The Institute is developing a 3D multigroup neutron transport simulation software, known as MORET 4. Based on the Monte Carlo method, this software is a major component of the CRISTAL criticality computation package. In 2005, the IRSN studied the possibility of using other specific or multigroup nuclear data libraries and carried out work with the aim of reducing computing uncertainties through the improvement of statistical methods used and improving the detailed analysis of calculation results. Some work is being carried out in the context of OECD/NEA supervised cooperation.
Criticality software packages are qualified by comparing calculation results with experimental data. It is for this reason that experimental criticality studies are being carried out in the context of national or international partnerships. These consist in setting up full-scale configurations with perfectly well-known radiochemical and geometric characteristics that are very close to the critical state. These experiments are then simulated by calculation. Calculations and experiments are then compared in order to assess the accuracy of the criticality software and to determine the margins of error to be adopted for criticality studies.
In 2005, the qualification of the MORET 4 software covered more than 1,300 experimental cases. Further experimental programmes conducted by the IRSN were started in 2005 *(see Focus right-hand page)*.

In the context of the optimisation of operations downstream of the fuel cycle in the USA, the aim of the US Department of Energy (DOE) is to validate a computing method which would allow spent fuel assemblies to be transported and stored more densely. Complex criticality calculations are required in order to demonstrate the safety of this densification.
In this context, the IRSN provided DOE with experimental results to validate criticality computer codes, taking into account the decrease in reactivity of the fuel assemblies after passing through a reactor (*burnup credit*). This experimental programme was conducted in the CEA's installations at Valduc with co-financing by Cogema and the IRSN (*see Focus right-hand page*). In addition, the Institute continued its participation in the international ICSBEP project in 2005. This project, under the auspices of the OECD/NEA, pools the results of criticality experiments conducted throughout the world for the qualification of

CRITICALITY RISK

The criticality risk, i.e. the risk of accidental triggering of a neutron chain reaction, exists at every stage of the fuel cycle (enrichment of uranium to form uranium 235, storage, transport, recycling of substances obtained after spent fuel reprocessing, disposal of waste products).

A criticality accident involves a release of energy, essentially in the form of heat, accompanied by intense neutron and gamma radiation emissions.

Criticality risk prevention entails determining the conditions in which subcriticality can be ensured during operations involving fissile materials. In addition, in order to ascertain the possible consequences of a criticality accident, the IRSN is carrying out studies and research in order to provide efficient computing tools with the highest possible degree of qualification.

criticality software. The IRSN presented its work on the reassessment of experimental data, from former criticality experiments, regarding annular cylinders containing plutonium solutions with or without the presence of solid "neutron poisons".

The Institute's research and development activities also include the acquisition of knowledge and the development of skills in order to allow for the burnup fraction in criticality studies. This is a feature of the new 1.0 version of the CRISTAL package which the Institute delivered to users in 2005.
In co-operation with EDF and the CEA, the Institute began, in 2005, processing the results of the experiments in the international REBUS[4] programme conducted by SCK.CEN (Mol) and BELGONUCLEAIRE in the VENUS installation at the Mol centre in Belgium. This work will show whether the reactivity effects due to irradiated PWR type UO_2 rods in experiments for the REBUS programme are sufficient to contribute to the qualification of criticality software.

In the field of critical accidents, the Institute carried out studies in 2005 concerning the consequences and possibilities of response in case of a criticality accident affecting transport containers. In addition, the co-operation that began in 2004 with Imperial College, which provides technical support on such matters to the British safety authority, continued in 2005 with counter calculations of reactivity transients representative of future experiments on plutonium solutions (planned in 2006) for comparison with the computing models *(see Focus opposite)*.

Dispersion of radioactive or toxic materials outside containments

The IRSN is carrying out studies and experiments in relation to various foreseeable accident situations to support the assessment of the risks of dispersion of radioactive or toxic materials outside containments. Work aimed at experimentally characterising the dynamic containment of a glove box in an accident situation has increased the range of results previously acquired as regards gas and aerosol transfer coefficients. It was thus shown that the containment's effectiveness features a minimum value depending on the flow rate, corresponding to the opening of a glove or bag port (failure of static containment). On the basis of the results

Experimental criticality programmes 2005-2008

[FOCUS]

Experimental device at Valduc for the performance of criticality experiments.

In 2005, an experimental device using low-concentration plutonium solutions was prepared and erected in the CEA's "Appareillage B" installation at Valduc, Côte-d'Or (France). The purpose of this device is to obtain experimental measurements of the effect of temperature (which may be positive) in the case of plutonium solutions of 15 g/l to 20 g/l. The experiments are planned for 2006.
In addition, a programme was started in 2005 in collaboration with two American laboratories in order to conduct criticality experiments in the IPPE BFS reactor in Obninsk (Russia) for ISTC. The objective is to carry out critical experiments representing industrial configurations using MOX type fissile materials.
Studies on the impact of uncertainties affecting the nuclear data for these environments will be conducted in the context of the experiments.
The IRSN gave CEA confirmation, in 2005, of its intention to use the "Appareillage B" installation at Valduc to conduct an experimental programme to qualify the neutron characteristics of the components of structural materials (steel, concrete, zirconium, aluminium, etc.). Owing to their ability to absorb neutrons, these materials are increasingly taken into account in criticality studies concerning transport, storage and disposal situations. The detailed design of the experimental device will be completed in 2006.

(4) REActivity tests for a direct evaluation of the burnup credit on Selected Irradiated LWR fuel bundles.

acquired, the concentrations of pollutants liable to be inhaled by an operator in such degraded situations can be assessed.
The work aimed at assessing transfers of radionuclides through cracked concrete were continued and tests on the retention of aerosols in dry air in a concrete wall were completed. Furthermore, a feasibility study on tests with an air and steam flow was conducted in 2005. The tests will be carried out in 2006.
The IRSN completed its experimental facilities for the characterisation of filters with the commissioning of a CATFISH test bench in 2005. This bench will study the effects of humidity on the clogging and efficiency of filtration with flat filter media and industrial folded filters. Preliminary tests were carried out to qualify the installation's performances and a multiannual research programme was started. Furthermore, the multiannual programme on the effects of wind on accidental releases was continued with the performance of wind tunnel tests on mockups representing nuclear installations. The design of an installation mockup with an internal ventilation system was also studied, to be used for wind tunnel tests for various accident scenarios.

Research on surface contamination of radioactive material transport packages

Since 2001, the IAEA has been supervising a "co-ordinated research project" regarding non-fixed surface contamination on radioactive material transport packages and vehicles. The aim of this project is to assess the validity of the current surface contamination limits (0.4 Bq/cm^2 for alpha emitter radionuclides and 4 Bq/cm^2 for gamma, beta or alpha emitter radionuclides with low radiotoxicity) and to update them if necessary. In the context of this project, the IRSN played a part in establishing scenarios for exposure to radiation resulting from the presence of surface contamination on packages and transport facilities. It also calculated the doses incurred for workers and members of the public for each of the 350 radionuclides included in the IAEA transport regulations, on the basis of a model prepared by one of the project's focus groups. Notably, the Institute considered that the results of these calculations did not call into question the current surface contamination limits. This work was published by the IAEA in a summary document, *IAEA-TECDOC-1449*, in June 2005.

RESEARCH WORK IN THE FIELD OF WASTE

In the field of waste, the IRSN mainly focused, in 2005, on drawing up a summary of research achievements in geological repositories for high-level long-lived (HLLL) waste and completing specific studies in order to prepare its report on Andra's *Dossier 2005 Argile*. This report was put forward to the Standing advisory group for radioactive waste long-term disposal facilities in December 2005.

The work carried out included the development of digital models and their validation by means of laboratory or field tests. Field tests were carried out in the Tournemire experimental centre (Aveyron) installed by the IRSN in a former railway tunnel excavated in a thick clay layer. The similarities between the Tournemire clay (argillite) and the rock studied by Andra in its Bure laboratory (Meuse) mean that the IRSN can use this tunnel to carry out studies that are not only methodological but also phenomenological. Tests were also carried out

Inserting instrumentation into a borehole.

in the experimental tunnel used by Nagra (the Swiss counterpart of Andra) in the argillaceous medium of Mount Terri (Switzerland) in collaboration with Andra.

Experiments on diffusion and retention of radioactive species

Multiannual experiments on the diffusion of radioactive or stable tracers are being set up at Mount Terri with the purpose of obtaining a better understanding of the behaviour of radionuclides and quantifying the effects of the rock's anisotropy on diffusion. In 2005, the experimental "niche" was excavated and its instrumentation was installed. The borehole will be equipped with a device with three blanking plates isolating two diffusion chambers. In the first chamber, highly interactive tracers will come into contact with the rock to study their diffusion. Tracers not fixed by the rock on the site will go into the second chamber where the effects of the anisotropy of the environment will be studied.
The introduction of the tracers is scheduled for 2006 and the decrease in the concentration of tracers in the chambers will be continuously measured until 2009.

Characterisation of excavation-disturbed zones

The IRSN started an exercise to model the zones disturbed by excavations (EDZ) around the Tournemire structures in 2004 in the context of the international DECOVALEX project. In 2005, an EDZ characterisation campaign by means of radial boreholes around the structures was set up *(see Focus*)*. The Tournemire site, which has structures of very different ages (one year, nine years and 110 years old), offers the possibility of studying changes in the disturbed zone over long periods. In 2006, the characteristics determined on site will be compared with results obtained by modelling. Furthermore, programmes for the digital simulation of the reaction of the rock to excavation were prepared in 2005 in the context of the European NF-PRO project (6th FPRD). They are to be used to interpret the results of the measurement of displacements, deformation and interstitial pressures obtained in 2004 in the context of the same projects for a mine-by-test operation (excavation in instrumented rock to monitor the rock's hydromechanical reaction).

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Characterisation of disturbances caused by rock excavation

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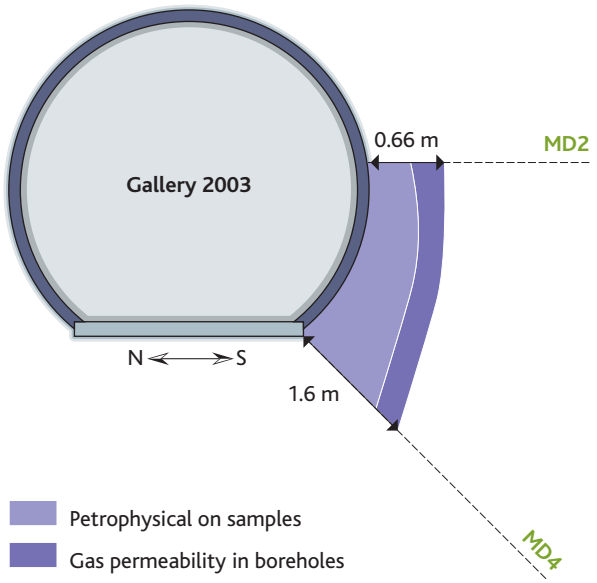

Extension of the desaturation zone around the gallery excavated at Tournemire in 2003.

Investigations were conducted in 2005 to characterise the damage to the rock around the underground structures of the Tournemire centre. Indeed, excavations disturb the rock, creating a damaged zone which is then liable to constitute a preferential migration path for radionuclides.
Geological observations and measurements on site and on sample cores (for changes in water content in the rock, hydraulic conductivity and speed of ultrasonic waves) were conducted by means of radial boreholes around the structures.

This work showed that the extension of the damaged zone remains limited to a ring situated between the wall and a distance of between 0.2 and 0.25 times the structure's radius.
The investigations carried out show, however, that the spatial distribution of the damage intensity and the orientation and density of the cracking caused vary according to the age of the structure. This could be the result of damage due to a combination of various basic physical mechanisms, such as the desaturation of argillite or deferred deformations. The detailed interpretation of these investigations and their comparison with the results of modelling operations will be continued in 2006 in the context of the international DECOVALEX and NF-PRO projects.

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Continuing the Common interest programme (PIC) on fires

Device for PICSEL_C tests under the SATURNE hood.

The PIC-Feux project (2003-2008), conducted in co-operation with Areva, includes in particular the PICSEL programme to study fires in electrical cabinets that could affect an installation with several ventilated rooms (clogging of very high-efficiency filters by smoke, disturbance of negative pressure levels in premises, etc.) as well as equipment containing radioactive material (glove boxes, bins, etc.).
The PICSEL_C tests for the study of the degradation of glove box equipment (gloves, glove ports, etc.) and waste drums subjected to thermal radiation simulating the effects of flame were conducted in 2005.
In parallel, the results of the PICSEL_A tests, carried out in 2004 to characterise an electric cabinet fire in an open environment were analysed. The programme was pursued in 2005 with the performance of one of the tests in the PICSEL_F series to study an electrical cabinet fire in a confined and ventilated location in the DIVA installation.
Furthermore, the clogging of filters by aerosols produced by fires fuelled by solids is being studied in the BANCO installation at Saclay. In 2005, special instrumentation was used to correlate changes in the air resistance of filters with respect to the characteristics of the primary particles comprising the combustion aerosols and the air flow conditions.
The empirical air resistance model previously constructed for the combustion of solvents can thus be modified for the combustion of solid materials such as those present in electrical cabinets.

Modelling the behaviour of a repository

In 2005, the IRSN continued working on modelling techniques to assess the containment capacities of geological repositories, taking into account the various barriers envisaged in the design options adopted by Andra in the *Dossier 2005 Argile*.
Studies were conducted in order to describe, in particular, the mechanical and chemical behaviour of a radioactive waste repository and the possibilities of transfer of radionuclides to the surface through the host layer and the more permeable, upper porous horizons. The hydrogeological modellings of the Paris basin and the Meuse/Haute-Marne site were updated. Prospective modelling exercises were carried out on flow modifications due to plausible climatic variations.

The MELODIE computer code was used to assess the containment capacities of a possible repository in the Callovo-Oxfordian formation, such as envisaged by Andra in its "clay" file (*Dossier 2005 Argile*), for operating situations classified as "normal" (probable) or "altered" (incident-affected).

In 2005, the IRSN played a part in preparing the two European projects for the 6th FPRD: PAMINA and MICADO dedicated, respectively, to computing methods and tools to assess the long-term performances of a deep repository and the influence of uncertainties regarding the radiological content of waste fuels on the overall safety of a deep repository.

Finally, in 2005, an agreement on technical co-operation regarding the exchange of experience concerning the utilisation of the MELODIE code was signed between the IRSN and AVN (Belgium), which provides technical support to the Belgium nuclear safety authority. This was a first concrete result of the approach for the outsourcing of the MELODIE code, adopted by the Institute in 2004.

RESEARCH WORK IN THE FIELD OF FIRE AND AIR DISPERSION

The IRSN's research in the field of fire concern the study of the behaviour of a fire in a confined and ventilated environment: fire propagation and consequences, smoke propagation to other premises. In the field of the air dispersion of pollutants, the Institute is continuing its work on controlling the containment of radioactive or toxic materials, reducing the uncertainties involved in assessing releases and their dispersion and, above all, assessing the human and environmental consequences.

Research programmes

The experimental approach offers the means of extending knowledge of the specific physico-chemical phenomena of fires and to supplement the database needed in order to develop and then validate models related to these phenomena. These models are then introduced into the computation software used to carry out studies to support the assessment of fire protection measures. Some programmes are carried out in collaboration with industrial partners, such as EDF or Areva, and are the subject of exchanges with other national and international organisations, such as INERIS, universities, US-NRC, etc.

The Common interest programme on fires (PIC-Feux), conducted by the IRSN in collaboration with Cogema and Areva, continued in 2005 with the performance of several tests in the IRSN installations at Cadarache (Bouches-du-Rhône) and Saclay (Essonne) *(see Focus left-hand page)*. The preparation of the PRISME programme continued with the performance of studies and the drawing up of knowledge status reports. The general purpose of the PRISME programme is to study in the DIVA installation the propagation of smoke and hot gases between rooms via doors or a ventilation system. This programme was successfully internationalised through the OECD *(see Focus*)*.

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Research on the modelling of the development of the power evolution of a fire fuelled by solid materials according to their chemical composition, the orientation of the fuel plate and the air flow in the vicinity of that plate were continued in the context

[FOCUS]

Setting up the PRISME experimental programme

Flame in the PRISME SOURCE S2 test under the SATURNE hood.

The PRISME research programme, dedicated to the study of the propagation of smoke and hot gases produced by a fire in a ventilated installation comprising several premises, was presented, in the second quarter of 2005, to fire risk experts from 10 OECD countries (Germany, Belgium, Canada, South Korea, Spain, Finland, Japan, Slovakia, Sweden and the United States) at a meeting organised by OECD/CSNI.

The possibilities offered by the DIVA installation, in which the tests are to be performed, aroused much interest as witnessed by the fact that practically all these countries joined the programme. In return for co-financing, they will take part in the precise definition of the experimental conditions and will have access to the results. On the French side, EDF and DGA will be partners in the programme. Scheduled to take place between 2006 and 2010, the programme will start up with a first test campaign called "PRISME DOOR". It will aim to characterise the transfers of heat and material via a door separating two rooms, one of which contains a fire.

of a thesis. The first test results were obtained in 2005 using a specific device located under the hood of the SATURNE tower in Cadarache. Two basic research topics regarding aerosols produced during a fire were also pursued in the Saclay installations: identification of the mechanisms placing volatile and non-volatile airborne contaminants in suspension, and characterisation of the soot emitted, in terms of morphology and optical properties. Finally, the experimental platforms used at Cadarache to study fires was completed with the construction of the CARINEA installation, a device designed for the study of small fires and which comprises a smoke collecting hood.

Simulation of a fire and its consequences

To simulate a fire in a nuclear installation and to assess its consequences in terms of containment of radioactive substances, two complementary approaches are used at the IRSN: a simplified approach using the FLAMME_S/SIMEVENT software and a detailed approach using the ISIS software.

The FLAMME_S/SIMEVENT software was used in 2005 to carry out studies prior to the tests in the PICSEL and PRISME programmes and calculations to analyse the test results from the DIVA0 campaign carried out in the DIVA installation in 2004. Furthermore, development of the SYLVIA software was continued with the aim of improving on the FLAMME_S/SIMEVENT software, which it will replace in 2006, for the calculation of the effect of ventilation on the development of fire and the calculation of the transport of particulate and gaseous species.

The ISIS software was used to simulate fires in a realistic configuration for several minutes *(see Focus opposite)*. This calculation tool is now operational for calculations to define IRSN tests and for the detailed interpretation of their results.

Owing to the complexity of ventilation systems in nuclear installations, their modelling requires the acquisition of a large number of measurements of their air flow characteristics. The IRSN is especially interested in drawing up a simplified modelling method for these systems requiring the acquisition of only a limited amount of air flow data but nevertheless able to realistically predict ventilation behaviour in specified situations *(see Focus below)*.

Research on air dispersion

The IRSN's work is aimed at assessing the physico-chemical phenomena relating to the suspension of contaminants and their transfer in normal and accident situations. They should contribute to the assessment of the containment of radioactive

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Development of the ISIS software

ISIS software developers.

The purpose of the ISIS software is to simulate 3D, incompressible or only slightly compressible flows governed by the effects of gravity and which are the seat of chemical reactions. It should be able to describe in detail the air behaviour and thermal behaviour of a room in which a fire occurs, whether it is ventilated mechanically or naturally. This software will help to improve the understanding of physical phenomena and confirm or reveal the limits of the simpler modelling technique currently used in the SYLVIA software.

In 2005, a version allowing calculations on several processors in parallel was developed. After a thorough test campaign to verify the satisfactory operation of the relevant numerical schemes and their computer programming, the first physical validation calculations were successfully carried out on fire tests conducted at the IRSN in ventilated premises. As the calculation software was judged to be sufficiently operational on the numerical and physical levels, it was then used, with success, to perform pre-test calculations for the "PRISME DOOR" tests to be performed in the DIVA facility in a configuration involving several rooms.

materials and help to reduce uncertainties regarding the assessment of releases into the environment.
In this context, the year 2005 marked the end of the *PIC Aérocontamination* (Common interest programme on airborne contamination) conducted with Cogema. The work carried out in this context led to the release of a database, BADIMIS V3, summarising knowledge on particle emission for various accident scenarios in installations (dropping of powder, air flow on a heap of MOX powder, etc.). In addition, research was carried out to study the suspension of contaminants from liquid sources.

In 2005, the IRSN conducted research on very small particles (on a nanometric scale) which pose special measuring and filtration problems. In order to study their possible effects on health, a thesis concerning the characterisation of the surface developed by a "nanoparticle" aerosol was started in collaboration with the INRS. Laser stripping techniques, which may be used to decontaminate the surface of materials, also produce nanoparticles. A thesis studying their formation during the interaction between laser and material was started in 2005 in collaboration with the CEA and Cogema.

In addition, research aimed at improving knowledge of the atmospheric dispersion of an accidental release of UF_6 was conducted in 2005 in the context of a PIC programme with Cogema. Using the CFX-5 multidimensional calculation software, it was possible to obtain a satisfactory simulation of the results of about 20 tests on the dispersion of a heavy gas in ventilated premises.
These tests were carried out in the IRSN's installations at Saclay, using a non-radioactive tracer (SF_6) instead of UF_6.

Experimental installation at Saclay to simulate the dispersion of a heavy gas.

Simplifying the modelling of ventilation systems in case of fire

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Full-scale blowing device to test the air flow and mechanical strength and compartmentation equipment behavior under pressure.

Interactions between an installation's ventilation system and a fire affect the fire's development and the containment of radioactivity within installations. A great deal of air data (pressures and air flow rates) is required in order to model the ventilation networks and transfers of physicochemical species, using the SIMEVENT software.

As all this data is generally not accessible, simplifications must be made according to the available data and the aim of the study.
In 2005, the IRSN established the initial basis for an approach to simplify the modelling of ventilation systems. The quantity of data required must be reduced as much as possible while ensuring that the reduced set of data defined in this way is adequate to correctly determine the consequences of the fire for a given scenario and objective.

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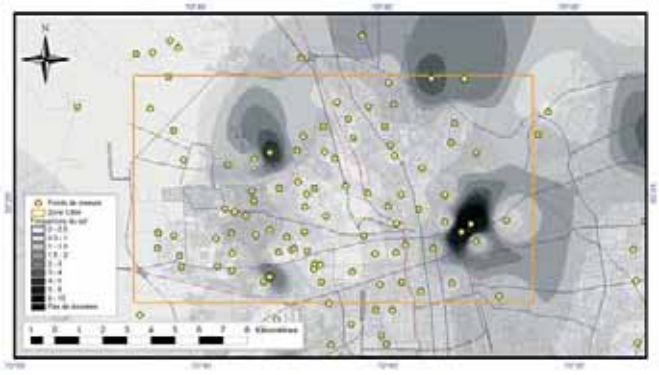
Agreement on co-operation with the University of Chile on seismic hazards



Map of points measured during the seismic background noise campaign conducted in Santiago de Chile (urban networks visible in the background of the figure) with the frequencies deduced from the measurements at those points in grey shading.

On 27 October 2005, the IRSN signed a co-operation agreement with the University of Santiago de Chile in the field of research on seismic hazards. This five-year agreement covers the performance of joint work on the modelling of strong ground movements, the propagation of seismic waves and site effects, and the vulnerability and behaviour of structures during an earthquake, along with the conducting of geological and paleoseismological studies. It also plans the organisation of training schemes and conferences for a mutual exchange of knowledge on these subjects. Under the agreement, a measurement campaign was conducted in Santiago in early April 2005 to determine the "urban background noise" at more than a 100 sites in the city. The ground characteristics will be mapped by processing the recordings taken. It is then planned to extend the measurements to the whole of the Santiago basin in order to create a 3D geometric model of this basin.
Once the geological model has been established, it will be possible to simulate strong motions caused by an earthquake on a fault recently recognised as active by geologists. As a result of these simulations, it will be possible to pinpoint areas in the basins that are the most at risk in terms of seismic hazards.

RESEARCH ON NATURALLY-OCCURRING HAZARDS: EARTHQUAKES AND FLOODS

The aim of the IRSN's work in this field is to improve knowledge of possible external hazards (earthquakes and floods) for installations at risk.

Research on earthquakes

In 2005, the IRSN's research on the workings of active faults and the characterisation of their "seismogenic potential" was continued, with the study of the Vuache fault (Jura) in particular. This fault has been the cause of several earthquakes over recent centuries, especially the Annecy earthquake in 1995 which led to significant material damage. The purpose of the study is to test a multidisciplinary method suitable for the French context, with low deformation rates. The study is based on field geometry, subsurface geophysical techniques and the analysis of aerial photographs.

In addition, the Institute continued to investigate site effects by undertaking work in an area exposed to high seismicity in Chile *(see Focus opposite)*. Modelling of ground motion leading to failure of a fault was continued in the context of two theses. The first, presented in 2005, concerns the prediction of seismic movements by empirical damping relations established on the basis of actual seismological measurements. The second thesis deals with digital modelling with the aim of reproducing the complexity of the failure in the fault plane and of seismic wave propagation phenomena in the geological medium.

Flood hazard for nuclear installations in case of a tsunami

Following the tsunami in the Indian Ocean on 26 December 2004, the IRSN searched for documents, in 2005, reporting on events of that type that may have affected French shores. This research clearly showed that a tsunami occurred on the British coast following the Lisbon earthquake in 1755, but there is no information on events of that type on

the French Atlantic shoreline. The IRSN then compared the criteria adopted for the dimensioning of protection systems for EDF PWR sites and a "reference" tsunami deduced from available observations, i.e. a rise of two or three metres in the sea level on the coast. This comparison showed that the existing protection systems for such sites could cope with a "reference" tsunami in mean tide conditions. Study is, however, being continued to determine the adequacy of the protection systems for a "reference" tsunami in maximum continuous tide conditions.

RADIOECOLOGY RESEARCH

The research conducted by the IRSN in the field of radioecology concerns the behaviour of radionuclides and their effects on ecosystems, whether they are the result of controlled or accidental releases. It is also aimed at achieving a better understanding of the spatial and temporal development of radioactivity in the environment. For the purposes of this research, the Institute has a high level of involvement in international projects.

Development of models, tools and expert assessment techniques

In order to be able to assess the impact of nuclear activities on the environment, the IRSN has, for many years, been developing and maintaining models and tools needed to predict the behaviour of radionuclides in the environment. In 2005, a new version of the ASTRAL software, jointly funded by EDF, was delivered. This software can assess the concentrations of radionuclides in the food chain following an accidental atmospheric release. In time, the ASTRAL software will be replaced by the SYMBIOSE modelling platform which will be able to model transfers of radionuclides within and between environmental compartments (aquatic, terrestrial and atmospheric). EDF's interest in the SYMBIOSE platform was confirmed in 2005 through its financial commitment to the development of the industrial version. Work began on drawing up the relevant specifications. In addition, the specific models developed for tritium and carbon 14 in 2004 were validated in 2005, notably by means of cross-comparison exercises.

Development of applied knowledge

Before models and tools are developed, the IRSN conducts experimental and field work in order to better understand the mechanisms governing the behaviour of radionuclides in the environment. In 2005, the topics covered by this work included atmospheric dispersion, with experimental campaigns in the urban environment in the context of the CAPITOUL project carried out in collaboration with the French meteorological department, Météo France, and transfers of carbon 14 and polonium 210 in marine species.

In addition, environmental data acquired in the field is also used in the context of research projects encompassing a variety of scientific disciplines. This is the case for two of the Institute's research projects, SENSIB and EXTREME, which reached the implementation phase in 2005.
The goal of the SENSIB project on "radioecological sensitivity" is to eventually obtain a tool to represent and compare, on the same scale, the sensitivity of various media to radioactive pollution. The consequences of pollution for man and the environment depend not only on the severity and nature of that

Micro weather station and SF_6 gas sampling devices used by the Octeville laboratory for the CAPITOUL project.

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Radioactive deposits linked with Saharan dust falling in France

During a Saharan dust episode, dust levels can be 15 times higher than usual.

In 2005, the IRSN launched a study, in the context of the EXTREME project, to define the relationship between the level of radioactivity in the atmosphere and the ambient dust concentration, with Saharan dust transport and deposit episodes representing the extreme dust levels. This type of event, limited in time and with a high intensity, currently results in the greatest atmospheric deposits of artificial radionuclides. As an example, on 21 February 2004, an exceptional Saharan dust transport and deposit event occurred in the southern half of France, sweeping an area of 300,000 sq. km. Readings of dust levels showed increases by as much as a factor of 15 compared with usual levels. Two million tonnes of dust were deposited during the episode, with deposits of up to 50 g/m^2.
Caesium 137 deposits measured after a few hours were equivalent to those estimated for the whole of 2003. However, the radioactivity added to soils on that occasion remained very low compared with that already present as a result of radioactive fallout from atmospheric nuclear tests and the Chernobyl accident (approximately 1/1,000).
Locally, resuspension phenomena on a much smaller scale are observed on a daily basis.
They currently govern the radioactivity background noise in the atmosphere near the ground.

pollution but also on the environment into which it is released. In 2005, work was started on factors of agricultural sensitivity in the context of a thesis on the utilisation of activity measurement results obtained since 1961 in the air-soil-plant-animal transfer system. As regards rivers, a post-doctoral study was undertaken on the part played by geomorphology in determining sensitivity factors on the banks of the Rhône. For the atmosphere, a thesis will undertake to establish the relationship between air mass wash-out coefficients and the characteristics of precipitation, i.e. the type (downpour, shower, drizzle, fog, snow) its intensity, its duration, the size of droplets and particles, the origin of the air masses, etc.

As for the EXTREME project, this is studying the environmental consequences of processes generating large flows or stores of radioactivity, such as storms and floods. Indeed, these events are liable to displace large masses of material and to result in radioactivity levels much higher than those determined by existing modelling techniques, as pollutant flows within a few days may often be equivalent to total flows in several months or event years *(see Focus opposite)*. The report launching the EXTREME project was circulated in 2005. This report was the result of post-doctoral work and a thesis on floods of the Rhône, and the beginning of a thesis on the forced redistribution of materials on the scale of the Gulf of Lions.

These two projects rely, in particular, on the development of environmental measuring equipment suitable for all media, implemented in the context of the Institute's OPERA measuring network. In 2005, a technical innovation was achieved by the Institute's laboratory at La Seyne-sur-Mer in collaboration with Harvard University. This consists in using a sensor, dubbed "Gellyfish", which is spontaneously balanced according to the surrounding environment and facilitates the measurement of concentrations of metal pollutants. This device can provide a standardised indicator of the concentration of contaminants in sea water, so facilitating the extension of marine observation networks, such as "Musselwatch", the international network for the observation of marine pollution in the Mediterranean, led by the IRSN under the auspices of the International commission for the scientific exploration of the Mediterranean sea.

Participation of the IRSN in European radioecology projects

Partners in the European FUTURAE programme under the leadership of the IRSN.

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Faced with the reduction in the means allocated to radioecology in Europe, the European Commission issued in 2005 a call for proposals, in the context of the 6th FPRD, to study the feasibility of a radioecology excellence network. This could be started up as part of the 7th FPRD. The purpose of this network would be to maintain and reinforce expertise in this discipline on a European and international scale. In response to the call for proposals, the IRSN took the initiative of forming and co-ordinating a consortium of 10 organisations from eight European countries and submitting a project named FUTURAE. After being appraised, this project was adopted by the European Commission. A consortium of six organisations was also set up in the context of the same call for tenders to compare the various methods of assessing the environmental risks associated with radionuclides. This consortium, which includes the IRSN, is co-ordinated by the UK's Centre for Ecology and Hydrology (PROTECT project). These two projects will start in mid 2006 and will last two years.

Sample core of sediment from the river Rhône (EXTREME project).

High level of international involvement

In 2005, the IRSN was strongly committed to international programmes, notably the European ERICA project aimed at providing a method to assess the environmental risks of radionuclides. In parallel, the Institute continued co-ordinating the activities of the IAEA group revising the TRS-364 guide regarding the parameters to be used in radioecological models (EMRAS programme). The IRSN also played a part in the writing of a Unscear report on environmental protection and prepared a mussel reference sample for a cross-comparison exercise in the context of the international Musselwatch network.

RESEARCH ON METROLOGY FOR RADIONUCLIDES IN THE ENVIRONMENT

The aim of research on the metrology of radionuclides in the environment is to improve and constantly adapt the techniques used in this field. This research supports radioecological studies in involving research on radionuclides in various contexts and, sometimes, in very small quantities. As a result of these studies, the spatial and temporal development of radionuclides released by nuclear activities can be understood and quantified.

In September 2005, the IRSN defined a reference point for the radiological situation around the new CERN accelerator, Large Hadron Collider, in Switzerland, by *in situ* gamma spectrometry. In this way, the Institute confirmed its mastery of this technique which is used by only four laboratories in France.
In situ gamma spectrometry provides a sensitivity equivalent to that obtained in the laboratory.

In situ gamma instrumentation near CERN to define the radioecological reference point (Geneva).

What makes it original is that it can give the specific activity in Bq/kg and the dose rate per radionuclide in less than one hour including installation on site, measurement and analysis. Another advantage is that a measurement representative of the site's mean value is obtained. In fact, laboratory measurements are performed on a sample weighing a few 100 grams which has to represent the site to be analysed, whereas the "sample" for *in situ* measurement is a disc which is more than 10 metres in radius and several tens of centimetres deep, i.e. several tonnes of material.
A thesis aimed at improving its utilisation in complex environmental configurations (with non-uniformly distributed radionuclides) is being prepared at the Institute's Orsay laboratory.

CHRONIC RISKS

The IRSN conducts research on the risks associated with chronic contamination in order to improve the radiological protection system. In 2005, the Institute pursued the development of tools to assess these risks for the environment and to gain further knowledge on the migration of radioactive elements in the ground. In parallel, the ENVIRHOM programme obtained major results to obtain better knowledge of the effects on man and the environment, and those results were presented to the scientific committee for this programme.

Assessment of chronic risks

Development of an environmental risk assessment method

The findings of the ENVIRHOM programme, along with study in the context of the European ERICA project, made it possible to design and develop a risk assessment method for ecosystems as regards the presence or release of radioactive substances. This assessment method is consistent with existing methods used for chemical substances.

Development of special tools for the expert assessment of chronic risks

Furthermore, a number of tools for risk expert assessments were developed in 2005:

- EDEN for dosimetric calculations required for the

study of the exposure of living organisms to radionuclides;
- the SYMBIOSE platform for models to calculate transfer in the biosphere and related databases;
- the FRED database for the effects of ionising radiation on non-human organisms, used by the IRSN to produce dose-effect relations in order to determine protection criteria for ecosystems.

Research on migration in non-saturated zones of soils

In parallel with its work on the biosphere, the Institute conducted studies in 2005 with the aim of obtaining better knowledge of the fate of chronic radioactive pollution in surface soils.
In this field, the EPIC project conducted on the Chernobyl site in collaboration with the Ukrainian IGS and UIAR research institutes led to the setting up of new instrumentation characterising transfers in the non-saturated zone of soils. As a result, through the chemical and radiological analysis of water at various piezometers installed around a trench of radioactive waste, it was possible to follow up the strontium 90 ("plume") originating from the trench. In addition, special attention was paid to the study of the transfer of plutonium and of its speciation (soluble and colloidal species).
The first stage of the CaPhéIne project regarding the migration of radionuclides in soils was conducted in collaboration with the National centre for research on polluted sites and soils (Douai, Nord). For this project, a lysimeter comprising contaminated sediments over a natural soil was instrumented with hydrogeochemical sensors.
As a result of the work for these two projects, it will be possible to develop the modelling of transfers of pollutants in a non-saturated zone constituting a route for the contamination of groundwater in the case of polluted sites or waste disposal areas.

ENVIRHOM programme

The ENVIRHOM programme, which started in 2001, deals with the risks related to chronic exposure to radionuclides with regard to both the environment and human health. An international, multidisciplinary scientific committee is assessing the quality and pertinence of the results obtained and gives its opinion on guidelines proposed by the IRSN.

Exposure of the environment

The results obtained in 2005, which are in line with the previous four years, confirm the pertinence of the ENVIRHOM programme.

- Knowledge of biogeochemical cycles of uranium and selenium

Advances in knowledge concerning the biogeochemical cycles of uranium and selenium in soils and sediments in ecosystems has made it possible to identify the routes via which living organisms can be exposed to those two radionuclides, and the relevant chemical forms, kinetics and intensity. When a radionuclide has been incorporated into a plant or animal organism, only a fraction is biologically active to trigger relatively early responses on the level of cells, tissue or the individual. For example, selenium and uranium inhibit the

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Presentation of the ENVIRHOM programme to the scientific committee

Presentation of the work on the ENVIRHOM programme to the programme's scientific committee at Vaux de Cernay

The scientific committee for the ENVIRHOM programme met for the third time on 22 and 23 November 2005. Researchers presented the most recent results obtained on exposure of the environment and man. The scientific committee expressed its satisfaction on hearing these reports and drew attention to the quality and scientific interest of the work presented. It noted the complementary nature of the studies conducted on man and those conducted on the environment, and suggested that those links should be strengthened. One of the committee's recommendations was to continue having results published and to target journals recognised by the scientific community.
The ENVIRHOM programme had 25 articles published in 2005.

growth of a unicellular green algae population according to a dose-effect relationship, with a threshold corresponding to a precise quantity of the element studied inside the cell.

■ Progress towards the modelling of effects on a population

On the basis of the experimental results obtained for a small freshwater crustacean, the effects observed for an individual exposed to an alpha emitter throughout its life cycle were extrapolated to an entire population. Initial results show that some effects observed on the individual level, such as decreased resistance to lack of food, could result in very severe effects for an entire population, including possible extinction.

Consequences for man of chronic uranium contamination

The first element studied in the ENVIRHOM programme was uranium, as it can be present at high concentrations in ground water in some regions, such as Finland, New Mexico and Canada. Studies are being conducted on rodents experimentally contaminated with uranium added to their drinking water (40 mg/l) for durations of variable length .

■ Effects on the central nervous system

Chronic exposure to enriched uranium affects the wake-sleep cycle, the working memory and the anxiety-like behaviour of the rat after 1.5 months of exposure. During the year 2005, these effects were correlated to the accumulation of uranium in two brain structures involved in controlling these behaviours: the hippocampus and the hypothalamus. This backs up the hypothesis of a direct effect of uranium on the central nervous systems. Furthermore, a modification of the metabolism of acetylcholine, the main mediator involved in memorisation processes is noted in the hippocampus, the cerebral zone involved in spatial working memory.

On the other hand, no significant modification was observed after chronic exposure to depleted uranium. Furthermore, its accumulation in cerebral structures is different from that of enriched uranium. These various results were published in 2005.

■ Effects on the metabolism of vitamin D

The P450 cytochromes (CYP) are a family of enzymes that plays a major role in the metabolism of exogenous substances (drugs, pollutants, pesticides, etc.) and endogenous substances (steroids, vitamin D, hormones, etc.).

In 2005, the IRSN studied the effect of chronic contamination with depleted uranium in the rat on certain hepatic and renal CYPs. The ingestion of depleted uranium for nine months increases the main CYPs, in the liver and kidneys, involved in the metabolism of drugs.

These results suggest that a course of treatment by drugs, given after chronic contamination with depleted uranium, could lead to hepatic and renal toxicity owing to an accumulation of toxic agents in those organs. If this hypothesis was to be confirmed, drug doses would have to be adapted for the treatment of persons subjected to chronic exposure to depleted uranium.

This type of contamination also results in an increase in the expression of a P450 cytochrome involved in vitamin D metabolism in the kidneys. Furthermore, some vitamin D target genes involved in the transport of calcium in the kidneys are stimulated by chronic exposure to uranium, thus reflecting a physiological impact.

In conclusion, the effects of depleted uranium on vitamin D metabolism could lead to calcium and phosphorous homeostatis changes or, even, the development or aggravation of some bone pathologies or some cancers, such as of the colon or prostate.

Experiment on growth inhibition in algae subjected to chronic exposure to uranium.

RESEARCH WORK ON RADON

Radon is a natural radioactive gas occurring all over the surface of the Earth. It accumulates in confined spaces, especially in buildings. It is due to the risk of lung cancer that work is carried out on radon and its decay products in the home. The IRSN is conducting research to develop tools to model the phenomena involved in the circulation and accumulation of radon in buildings and in water.

Understanding the radon concentration mechanisms in buildings

An experimental programme aimed at understanding the mechanisms affecting radon concentrations in buildings was completed in 2005. Instrumentation was installed in a detached house in Kersaint (Finistère) to determine the penetration of radon through the basement slab and its half-buried walls, its accumulation in the building and its distribution between the floors as a result of air circulation and exchanges with the outside.

The data collected in this way was used to test the RADON 2 code, developed at the IRSN. This code is to provide a generic description of the accumulation of radon in a building.
The goal is then to provide an efficient diagnosis tool to assist in the management of the radonhazard and able to "predict" the activity concentration of this gas in dwellings located in areas with a high potential for radon exhalation or on polluted sites.

The ground under the building is not always the main source of the radon measured indoors. Other sources, such as building materials, can sometimes play an important part. A bibliographic analysis showed that the disparateness of studies on the exhalation of radon from building materials made it difficult to use them. In the absence of any clear trends, tests are planned on the Kersaint experimental site. Their aim is to determine how much building materials contribute to the activity concentration of radon measured in the house at Kersaint.

Instrumentation in the house in Kersaint (Brittany).

Radon, tracing water circulation in fractured media

Variations in the activity concentration of radon in groundwater in fractured media have been studied on a site in Morbihan (France), since 2004. This research is aimed at improving knowledge of the behaviour of radon in water according to the hydrology, fracture systems and rock properties. In 2005, work was conducted, in particular, on tests to validate models to calculate radon concentrations in water on the basis of the characteristics of the medium.
Ground water in fractured water-bearing formations can constitute non-negligible radon sources, especially in granitic regions. The objective is to better understand the production and transfer of radon in a heterogeneous medium so that it can be taken into account in the management of radon hazards.
This work is being conducted as part of a project set up in Brittany.

Measurement of radon and its decay products

It is known that the risk of lung cancer associated with exposure to radon is not due to the radon itself but to its short-lived decay products. These occur in the form of aerosols, i.e. particles in suspension in the air, some of which are inhaled and are deposited in the lungs. These nanometric particles become fixed on atmospheric dust and are transported by that dust in confined spaces.

The IRSN is conducting research in order to improve its basic knowledge on the physics and metrology of radon and its decay products, so that radon measurements in the field may be considered to provide a reliable indication of the risk. The Institute collaborated with the University of West Brittany to develop and qualify an instrument to measure the size distribution of the free fraction of radon decay products, as this is an indispensable parameter in order to determine their behaviour in a closed volume and their deposit in the respiratory tracts. In the context of this collaboration, a thesis was started in October 2005 to study the electrical charge of these decay products, as this is another parameter affecting deposits. This work benefits from the technical environment developed around the IRMA irradiator and the calibration bench for BACCARA radon dosimeters. This equipment is also used for other applied scientific research projects and to provide calibration services for radon measuring instruments.

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Quantification of cancer risks

Alpha-Risk: a European programme.

The Alpha-Risk research project, financed by the European Commission and co-ordinated by the IRSN, was started in July 2005 for a period of three years. This project seeks to improve the quantification of cancer risks associated with chronic internal exposure and, in particular, exposure to emitters such as uranium, plutonium and radon and its decay products. It includes the principal epidemiological teams in Europe which are monitoring populations with a precise record of individual dosimetry.

The Alpha-Risk projects is backed by 18 partners from nine countries and relies on the collaboration of experts in the fields of epidemiology, dosimetry, statistics and modelling. The project is intended to specify the effects of low or repeated doses and should lead to a consensus on the best assessment of the risk of lung cancer attributable to radon decay products, in smokers and non-smokers. It is expected that a summary of the risks associated with low doses will be drawn up as a result of the Alpha-Risk project.

EPIDEMIOLOGY OF NUCLEAR WORKERS

The IRSN continued its epidemiological activity in 2005 with a view to enhancing the assessment of cancer risks associated with chronic exposure to low doses of ionising radiation.

The IRSN is monitoring a cohort of workers from the CEA-Cogema group in order to estimate the risks of cancer associated with occupational exposure to ionising radiation: exposures that are low but chronic. This assessment entails determining the individual doses received by the workers throughout their careers, searching for their vital statistics and, where applicable, the cause of death. A total of more than 50,000 workers are involved.

Common interest programme in epidemiology

A Common interest programme (PIC) funded by Cogema and the IRSN is studying the health effects in a number of workers exposed to low levels of ionising radiation. This three-year programme, which started in 2004, relies on close co-operation between the IRSN's epidemiological laboratory and the Cogema occupational medical department. It comprises three studies.

▸ In 2005, the IRSN continued the analysis of the

deaths of a cohort of French uranium miners. The work carried out entailed extending the follow-up of that cohort and analysing causes of death until the end of 1999. A study to determine the smoking history of the miners was carried out in order to allow for the part played by tobacco in occurrences of lung cancer. The new results confirm the existence of supplementary deaths due to lung cancer associated with exposure to the decay products of radon accumulated over their entire working life.

> The study into the deaths of the Cogema workers concerns more than 10,000 individuals, followed up from 1976 to 1994. An initial report was drawn up in 2005 and this showed there was no increase in mortality within the group of workers compared with the general population of France. The study of the risk of death caused by cancer in relation to cumulated exposure is continuing.

> The IRSN also tested, in 2005, the feasibility of a morbidity study of Cogema workers (Ile-de-France plant). This study is especially interesting in order to determine the rates of occurrence of pathologies with a low mortality rate. The first step involves the data collected by the occupational medical department at Cogema's Ile-de-France plant. It will then be extended to other sites. The purpose of the feasibility study is to test all the tools required to collect all the relevant diagnoses (cancers, and other chronic and acute illnesses) and, in parallel, to provide access to other tools outside Cogema (regional cancer registers, other sources of information, etc.). This morbidity study would provide a management tool for the Cogema occupational medical departments while also making it possible to obtain more accurate results in the study of Cogema workers, which is currently based on mortality data.

Installation of dosimeters to measure the exposure of fingers when using a syringe shield in nuclear medicine.

Team of epidemiologists.

IMPROVEMENTS IN RADIOLOGICAL PROTECTION

The IRSN regularly improves its methods and tools to assess the exposure of personnel to ionising radiation to provide better radiological protection for workers, patients and the general public.

In nuclear installations, workers are exposed to various risks of external irradiation, internal contamination and via the skin. Their protection is ensured by various devices studied by the IRSN to check, in particular, their reliability in case of accident and to improve their effectiveness.

Study of the performances of syringe shields used in nuclear medicine

In nuclear medicine, some acts require a radioactive marker to be injected into patients. This marker contains a radionuclide which acts as a tracer, generally combined with a molecule that has the property of attaching itself to specific cells in the organism. The current trend shows increasing use of yttrium 90 (β^- emitter). When radiopharmaceutical solutions are handled, the technician's hands, in

particular, are exposed to the radioactive sources whose activity levels are in the vicinity of 1 GBq. Radiological protection devices such as syringe shields are therefore used when injecting patients. In the course of 2005, the IRSN developed a digital tool to evaluate the performances of these devices and to propose improvements in order to reduce exposure of the hands. This tool was validated by comparing the results with experimental data obtained, notably, in collaboration with the Gustave Roussy Institute's nuclear medicine department. In the case of yttrium 90, it was confirmed that a tungsten syringe shield 5 mm thick provided the hands with protection three times greater than that provided by a 1 cm thickness of Plexiglas. In addition, a simple modification of the tungsten device, by adding a few millimetres of Plexiglas, reduces exposure by a factor of 2. Similar studies were conducted for the injection of fluorine 18 (β^+ emitter).

Preparation of calix[6]arene molecules for use in the analysis of actinides

One of the methods of monitoring workers exposed to a risk of internal contamination by α-emitter radioelements is to measure these radioelements in their urine. The current analysis methods require long, complex chemical treatments. In 2005, the IRSN conducted research to develop new protocols for the analysis of α-emitter actinides in urine and stools offering better performances in terms of sensitivity and response time in order to improve the monitoring of exposed workers.

The benefit of using calix[6]arene molecules to selectively isolate U, Pu and Am actinides in urine was demonstrated. These molecules effectively allow the selective extraction of these three actinides in a quantitative manner. The invention developed by researchers from the IRSN concerns the embedding of calix[6]arene molecules on media with a view to using them to analyse U, Pu and Am actinides in urine. A patent application for this invention was filed on 17 May 2005. After being optimised and validated, the protocol developed should make it possible to chemically treat the urine in one day instead of the three days required by the protocols used at present. This topic was also the subject of a thesis presented in 2005.

Inauguration of the AMANDE installation.

Model for internal contamination by injury

There is little available literature on the biokinetic behaviour of uranium in the case of internal contamination by injury. At present, the ICRP does not propose any model for this type of contamination. It is for this reason that a study was started by the IRSN. In the first stage of the study, conducted in collaboration with the Cogema occupational medical department, a review of the various types of contamination by injury occurring in the fuel cycle industry was drawn up. The next stage in the study concerns the modelling of internal contamination by uranium after sustaining an injury. It is based on *in vitro* uranium transfer experiments on pieces of skin, with *in vivo* validation on rodents. The purpose of these experiments is to simulate the main types of injury listed.

In 2005, data regarding the transcutaneous passage of uranyl nitrate in an aqueous solution for healthy skin and for damaged skin were obtained *in vivo* in the rat. They confirm and reinforce the results of experiments conducted *in vitro* on pieces of rat, pig and human skin. In conclusion to this work, it appears that, like inhalation and ingestion, the cutaneous route allows the incorporation of uranium whether the skin is damaged or not. This could be the origin of some internal contaminations observed by occupational medical departments and that have hitherto remained unexplained.

The mathematical modelling of the distribution kinetics of uranium in the organism after contamination via injury is currently in progress.

THE AMANDE INSTALLATION

The IRSN opened its new AMANDE research installation on the Cadarache site (Bouches-du-Rhône) on 20 May 2005. The primary aim of this installation is to determine the response of neutron measuring equipment in relation to the energy of the neutrons, as recommended by international standard ISO 8529-1.

The AMANDE installation was designed to generate monoenergetic neutron fields of metrological standard, with energy adjustable between 2 keV and 20 MeV by means of a specially designed particle accelerator. The project was started in 2000 and the installation will be operational in 2007.
The phase for the setting up of the detection and qualification systems for the charged particle beam and neutron fields started and is scheduled to last two years. The AMANDE installation will make the IRSN neutron metrology and dosimetry laboratory a reference for neutron dosimetry on the national, European and international level.

RADIOLOGICAL PROTECTION IN THE MEDICAL FIELD

Radiotherapy treatment can have acute and delayed secondary effects, such as fibrosis. These side-effects are caused by damage to healthy tissues exposed to the radiation field. New therapeutic approaches must therefore be developed to provide better protection for healthy tissue.

Therapeutic utilisation of statins such as anti-fibrosis agent

In 2005, the joint UPRES EA 27-10 unit (IRSN-Gustave Roussy Institute) determined the general mechanisms for the development of radiation-induced fibrosis *in vitro* and *in vivo (see Focus below)*.
A new therapeutic approach for fibrosis using statins was also tested in 2005. In rats, treatment with pravastatin after irradiation showed a preventive action on the development of radiation-induced intestinal fibrosis.
Thanks to these results, it was possible to offer this treatment on a clinical basis in order to limit delayed complications of therapeutic radiation and so improve the quality of life of patients treated by abdominal-pelvic radiotherapy. A clinical study is being prepared to assess the protective effect of pravastatin.

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Work will continue at UPRES EA 27-10

The research centre adjoining Gustave Roussy hospital in Villejuif

In 2005, the French Ministry for Research renewed its backing for the UPRES EA 27-10 laboratory for the third time for a further period of four years. The UPRES EA 27-10 unit (IRSN-Gustave Roussy Institute) is one of the very few French laboratories studying the biological bases of radiotherapy and its consequences on healthy tissues. The unit's studies are based on a combination of intestinal physiology, molecular studies and the development of original experimental and cellular models with a view to determining the general mechanisms of radiation-induced fibrogenesis.
Two preclinical studies in animals were completed in 2005. They showed the therapeutic benefits of using GLP-2 and statins on the development of radiation enteritis. This research was conducted in association with the pharmaceutical industry (Novonordisk and Bristol-Myers Squibb). A first clinical protocol, marking the completion of this research work, was proposed to study the clinical efficacy of pravastatin after radiotherapy.

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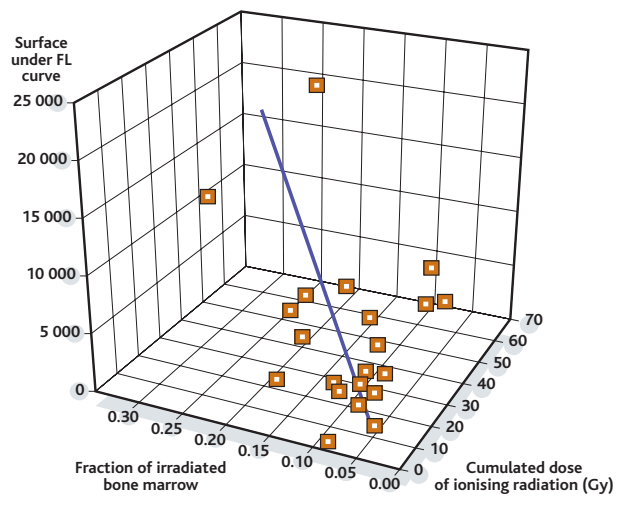
Bio-indicator of damage to bone marrow



Relationship between FL concentration and overall damage to the bone marrow.

In case of accidental irradiation, damage to the bone marrow can constitute a serious problem for the organism. Disturbances in the formation of blood cells (haemopoiesis) may occur, so leading to infectious and haemorrhagic risks which may affect the vital prognosis of an irradiated individual. It is essential to assess the residual haemopoiesis in order to choose a therapeutic strategy, as it is of paramount importance in order to decide whether or not a bone marrow graft should be performed.
In 2005, the IRSN continued its studies on research in bio-indicators of damage to bone marrow after irradiation.
The regulating mechanisms of the Flt3 ligand, a molecule playing a part in the control of haemopoiesis, were studied after irradiation for a thesis presented in 2005.
A heterogeneous irradiation model with variable percentages of irradiated bone marrow was developed for the mouse.
The results show that variations in the concentration of Flt3 ligand in the blood can be used to directly assess radiation-induced damage to the bone marrow.

IRRADIATION AND CONTAMINATION ACCIDENTS

The work carried out by the IRSN on the effects of medium and high dose irradiation concerns effect bio-indicators for diagnoses and, even, prognoses, research on new therapeutic targets, and the development of operational measurement systems to complete diagnosis tools.

Improving diagnoses

Reference curves for irradiation at high doses

Improving diagnosis methods for accidentally irradiated persons remains a major priority at the IRSN. In Biological dosimetry, the conventional technique used is based on the number of chromosomal aberrations and dicentrics in lymphocytes isolated from a blood sample. This technique, however, has limitations for doses higher than 5 Gy.
In the course of 2005, the IRSN developed a new methodology for the drawing up of reference "dose-effect" curves specifically adapted to irradiation at high doses (higher than 5 Gy) in order to complete the set of existing curves.
This methodology is especially suitable for criticality accident conditions. It allows both high exposure doses (more than 10 Gy) and the mixed gamma/neutron flow to which victims are generally exposed to be taken into account. For this purpose, gamma irradiations and mixed gamma/neutron irradiations at between 5 and 25 Gy were applied to blood samples.
A method of achieving the early condensation of chromosomes by means of chemical molecules from lymphocytes obtained from the samples was adopted and another type of chromosomal aberration, known as centric rings, was used. These anomalies are 10 times less numerous than dicentrics and only reach a saturation plateau at much higher doses. Using the reference curve thus obtained, the ratios of centric rings observed in victims of the criticality accident at Tokai-Mura (Japan) gave exposure doses that were consistent with those determined by physical dosimetry.

The IRSN now has a set of reference curves covering accident situations and activities in various industries.

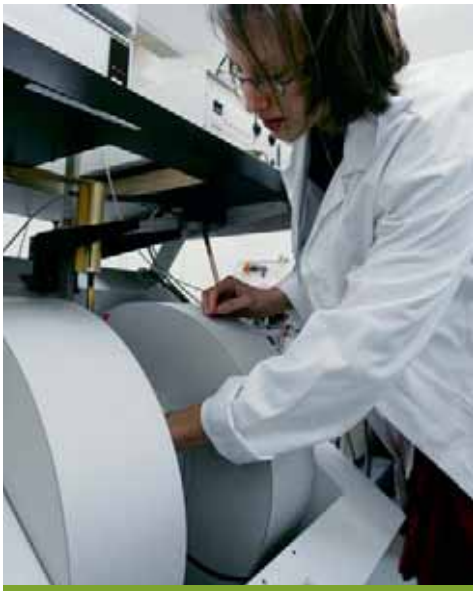
This work is the fruit of collaboration between the IRSN and the Centre for health and protection against radiation (CPHR) in Cuba.

Dose assessment by electronic paramagnetic resonance (EPR) in case of radiological accident

The IRSN uses EPR spectrometry as a dosimetry technique to assess the doses received by victims of external exposure to ionising radiation. Dosimetry is used to estimate the amount of irradiation and to establish the best possible diagnosis so as to define the most suitable therapeutic strategy. This method is being developed with the aim of increasing the Institute's operational efficacy.

The corresponding studies in 2005 consisted in selecting materials which may have been located in the victim's environment, such as sugars, and determining their dosimetric properties in a photon field and in a mixed neutron and photon field. The results showed, in particular, that the materials studied have interesting dosimetric characteristics, i.e. a linear dose response and a response independent of radiation energy.

The IRSN also created a database of conversion factors between the doses received at one or more points of the body, measured by EPR, and the doses received by organs or the whole body. Factors of this type were systematically calculated in standard and realistic irradiation configurations for photon, neutron and mixed fields. This database provides the Institute with a tool giving a first assessment of the dose distribution within a very short time. All the studies were carried out for the purpose of a thesis to be presented in 2006.



Dose assessment by EPR.

Research into new therapeutic options for accidental irradiation cases

Utilisation of mesenchymal stem cells

Cellular therapy entails providing the organism with cells capable of repairing its damaged tissues. The work undertaken by the IRSN is being carried out by a mixed team from the IRSN and Saint-Antoine hospital (UPRES 16-38). It concerns the possibility of adapting the principles of cellular therapy to the case of victims of accidental irradiation in order to correct cellular deficits which may have immediate or delayed consequences for the organism.

The mesenchymal stem cells (MSC) in the bone marrow are multipotent cells, i.e. they are able to proliferate and differentiate into many types of cells. These properties offer prospects in the field of regenerative medicine. The work carried out at the IRSN in 2005 consisted in studying the possible use of MSCs for the treatment of radiation-induced tissue damage and, especially, for the cellular therapy of radiation-induced intestinal damage.

Immunodeficient mice were transplanted with human MSCs 24 hours after local high-dose irradiation of the abdomen. The regenerative capacity of the MSCs was studied on the intestine. The results showed that transplanted MSCs are engrafted in the intestine and limit radiation-induced morphological changes to it. The cellular effects of MSCs during the structural regeneration were characterised. MSCs reduce the mortality of intestinal cells and increase the proliferation capacity of the cells in the crypts of the intestinal epithelium, a compartment where the intestinal stem cells are located. As a result of this study, it should be possible to establish a relationship between the capacity of MSCs to regenerate the intestinal structure and the possible functional restoration of the intestine.

MANAGEMENT OF POST-ACCIDENT SITUATIONS

In 2005, the IRSN's main studies on the management of post-accident situations were focused on the definition of approaches and tools to respond to accident situations and to deal suitably with their consequences.

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Completion of the contract with DGA on molecular therapeutics

Histological cross-section of irradiated intestine.

The year 2005 saw the completion of two years' work by the IRSN under contract with the French General Delegation for Armaments (DGA). The aim of this work was to study the part played by intestinal damage in radiation-induced multiple organ failure syndrome. For this purpose, the efficiency of therapeutic approaches targeting the intestine was tested in mice, after exposure of the abdomen area to high doses of irradiation (between 15 and 20 Gy). One of the therapeutic strategies consisted in reducing the radiation-induced inflammatory reaction by taking action quickly after the exposure. Thus, the results obtained show that, in conditions where the intestine is severely damaged both morphologically and functionally, steps to quickly control the inflammatory response can increase the survival rate and reduce structural and functional intestinal damage in the irradiated mouse.

Work on the European level

Environmental rehabilitation following an accident

The assessment of possible rehabilitation actions in agricultural and built-up areas after a nuclear accident is being studied in the European EURANOS programme. In 2005, the IRSN continued to lead a group of interested parties in France (agricultural technical institutes, local government departments, elected representatives and experts) that have the task of assessing a European decision guide regarding the decontamination operations to be performed in built-up areas.

Consensus on medical treatment in case of a radiological accident

In October 2005, the European Group for Blood and Marrow Transplantation (EBMT) and the University of Ulm (Germany) organised a conference at Vaux de Cernay (Yvelines) in order to establish a European consensus on medical treatment in case of a radiological accident, including as a result of terrorism. After a review of the specific features of an irradiation accident and of medical management, the participants defined the most suitable medical treatment.

The results from focus groups were pooled to reach a consensus on many aspects of diagnosis and therapeutic strategy. This consensus concerns, in particular, treatment with cytokines and therapeutic indications for bone marrow transplantation, which had been fully debated over several decades.

This consensus represents an important stage in the approach to harmonise medical treatment for many victims in case of a radiological incident.

Modelling tools for atmospheric dispersion

The IRSN collaborated with two university establishments in 2005 to create tools to model the atmospheric dispersion of an accidental radioactive release.

The first collaboration, with the *Ecole Centrale de Lyon*, concerned the development of the pX model for local atmospheric dispersion, i.e. within distances of 30 km from the point of release.

The second, with the *Ecole Nationale des Ponts et Chaussées*, was for the development of the IdX long-distance dispersion model, the modelling of the behaviour of aerosols and the implemen-

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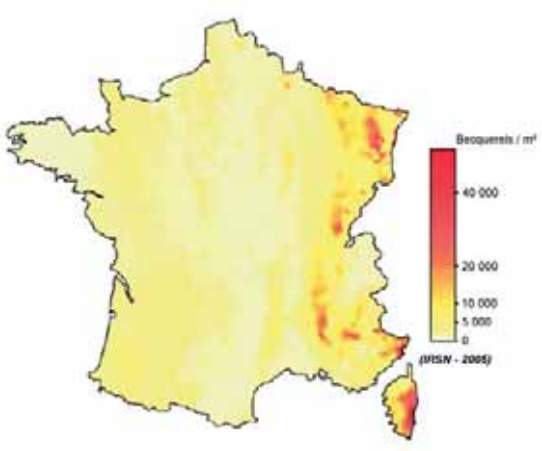
Analysis and quantification of atmospheric fallout in France following the Chernobyl accident



Map of France showing caesium 137 deposits on the ground as a result of the Chernobyl accident (May 1986).

The IRSN conducted and completed a study, in 2005, with the aim of improving the analysis and quantification of the phenomena causing the atmospheric fallout of caesium 137 in France after the Chernobyl accident.
This study was based on the collection and interpretation of relevant data concerning the contamination of soil and air, along with the amounts of rainfall between 1 and 5 May 1986. It confirmed the considerable influence of wet fallout in the occurrence of caesium 137 depositions in May 1986, already identified during previous work presented in 2003. It showed deposits of the same level as previously. In particular, deposit variability factors, which could result, locally, in higher values in some departments of Easter France (Corsica, Alpes-Maritimes, Drôme, Jura, etc.) were studied, along with the influence of the proportion of wet deposits on the contamination of plants and, thereafter, of the food chain in May 1986.

Furthermore, as a result of this work, it was possible to confirm and specify the benefits and contents of current projects at the Institute with the aim of boosting its capability of assessing radiological consequences in post-accident situations:
- future developments of the atmospheric aerosol monitoring network;
- development of a code for the long-distance atmospheric dispersion of radionuclides (IdX);
- study of atmospheric wash-out of aerosols during rainy periods, using observation results from the IRSN's OPERA network;
- development of an assessment approach based on the sensitivity of environmental compartments subjected to radioactive contamination.

tation of methods to apply the measurement results in the environment by means of models.
In this way, the first version of the pX model was developed and work on the scientific qualification of both models was started.
In addition to this qualification process, a "research" version of the IdX tool was tested by reconstructing the dispersion of radioactivity resulting from the Chernobyl accident *(see Focus above)*.

INTERNATIONAL PROGRAMMES AND AGREEMENTS

The IRSN's research activities on the European level expanded in 2005. Its work in connection with the Franco-German initiative for Chernobyl was completed and bilateral co-operation projects were stepped.

Research in the European context

The European Commission's framework programmes for research and development (FPRD) played a

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Tripartite co-operation in case of radiological accident

Dose assessment by biological dosimeter.

The IRSN signed an agreement in 2005 with Britain's Health Protection Agency (HPA) and the German organisation, *Bundesamt für Strahlenschutz* (BfS), allowing any of the signatory countries to call for assistance from all the biological dosimetry laboratories in the other countries in case of a radiological accident.
This agreement should make it possible to obtain a dose assessment in a crisis situation three days after the taking of a blood sample, and so help medical teams to implement the optimal therapeutic strategy.

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Franco-Russian co-operation

The IRSN has been co-operating with the Russian federal agency for nuclear energy (Rosatom) for many years in a context defined by the CEA. During the CEA/Rosatom committee meeting held in December 2005, it was decided that the IRSN would, from then on, be a full member of this arrangement.

Co-operation between the IRSN and Rosatom mainly concerns the physical protection of nuclear materials, radiological protection, criticality and crisis management. The year 2005 was significant owing to the renewal of co-operation in the field of radiological protection, through the signing of a co-operation agreement with the Moscow Institute of Biophysics regarding, at a first stage, accident dosimetry, radiation pathology and biological dosimetry.

part in the sharing of knowledge and the resources required to carry out research, notably in the nuclear fission field. They also allow European laboratories to compare their results and foster the creation and development of research networks.
The IRSN is involved in 11 projects in the Euratom part of the 6th FPRD (2002-2006), including co-ordinating the network of excellence on the physics of severe accidents in pressurised water reactors (SARNET) and the project to assess chronic risks due to alpha radiation (Alpha-Risk). The Institute also took a very active role in proposing 11 new projects for the last call for tenders in 2005.

In the context of the general FPRD, the IRSN is participating in the FIRST project on the protection of healthy cells subjected to radiotherapy and in the ETPIS technological platform which includes some 170 European organisations working on the safety of industrial installations subject to hazards such as fire and explosion. The Institute is also preparing to participate in safety research projects which will be developed in the context of the 7th FPRD.

Situation report in the Franco-German initiative for Chernobyl (FGI)

An initiative to deal with the consequences of the Chernobyl accident was launched 10 years ago by the French and German Environment Ministers in co-operation with Ukraine, Belarus and Russia. The implementation of this initiative, under the responsibility of the IRSN and its German counterpart, GRS, mobilised more than 30 Ukrainian, Belarussian and Russian institutes with €6 million funding provided, in equal shares, by the French and German governments, EDF and the German electricity group, VDEW.
The aim of FGI was to gather all existing data on the safety of the sarcophagus, the impact of the accident on the environment and its consequences for the health of the populations concerned in the three countries, in order to create a reliable database useful for the planning of countermeasures, public information and scientific and technical work in those three fields. The databases completed in 2005 are now accessible on the Chernobyl Centre website (**www.fgi.icc.gov.ua**).
Thanks to these databases, progress has already been made in the three fields mentioned:

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Studies of pathologies in children in Bryansk *oblast*

Measurement of caesium 137 in children in Bryansk *oblast*.

The IRSN set up a study named EPICE in October 2005 with the aim of measuring the caesium distribution in children living in the Bryansk region, which was the most contaminated area in Russia, and of checking whether there was a link between their levels of caesium contamination and the pathologies observed.
The purpose of this study is to provide answers to the questions raised by the work of Dr Y. Bandazhevsky, which suggest that the children living areas contaminated by releases from the Chernobyl nuclear power plant may be affected by unusual pathologies such as cataracts, gastroduodenal ulcers and cardiac dysrhythmia.

The IRSN's work is carried out with the collaboration of physicians from the Bryansk clinical diagnosis centre (BCDC) and dosimetry specialists from the Obninsk medical centre for research on radiation (MRRC). A group of 49 children living in contaminated areas was formed on the basis of medical follow-up data on inhabitants of Bryansk *Oblast*.

Teams from the IRSN, BCDC and MRRC conducted measurements of the distribution of caesium 137 in the body, especially the heart, thyroid gland and liver, for each child. They also gave the children full medical check-up, including cardiogram and scans of the thyroid gland, liver and heart.
Using the results of this study, which are expected in the course of 2006, it should be possible to specify the impact of caesium 137 contamination on non-cancerous pathologies in the individuals exposed.

- the data gathered regarding the safety of the sarcophagus were supplied to the Shelter Implementation Plan, managed by EBRD, in order to optimise the agreed international effort to place the remains of reactor no. 4 of the Chernobyl power plant in a safe situation;
- the use of data concerning the environmental effects of the accident has made it possible to improve some radionuclide transfer models which would be used in the management of a nuclear crisis;
- The data regarding the accident's consequences for the health of populations, especially as regards cancers (solid tumours and leukaemia), congenital malformations and infant mortality, represent a very major contribution to the study of the conditions in which these problems occur.

The IRSN and GRS organised discussions with their foreign partners and international organisations in 2005 with the aim of facilitating wide utilisation of the data assembled, perpetuating and enriching the databases and furthering the work carried out in the fields of health and the environment, especially post-accident management.

French-Indian co-operation

The co-operation between the IRSN and India's Bahba Atomic Research Centre (BARC) was defined by an agreement signed by both parties in July 2000.
After focusing on questions regarding reactor containments and cores, it was extended to radiological protection in 2003.
Discussions were held on the broadening of the agreement in 2005. New topics including, in particular, the assessment of the safety of radioactive waste disposal facilities, methods of assessing uncertainties in accident thermal-hydraulics and epidemiology were added.

In this context, the IRSN hosted three BARC experts in 2005 in order to start work on the validation and adaptation of the ASTEC and ICARE/CATHARE codes. This work is now being continued at BARC.
The Institute also actively participates in meetings organised in the context of French-Indian discussions on nuclear safety. It was agreed, in October 2005, that a seminar on methods of assessing uncertain-

Visit of the French delegation for French-Indian discussions on safety - Madras nuclear power plant, 26 October 2005.

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The IRSN defines its position on environmental radiological protection

The protection and monitoring of the environment have always been matters of great concern for the IRSN.
In response to the increasing emphasis on environmental preoccupations over the last decade, the IRSN has set out its general strategy for the development of an environmental radiological protection system. The position statement, published by the IRSN in 2005, describes the development of practices in this field, the current state of knowledge and knowledge that should be acquired in order to consolidate a method to assess the environmental risks associated with radionuclides.
This document also considers the consequences of this approach on environmental monitoring strategy and the resulting implications for the Institute's relationships with its national, European and international partners.
For further information, visit
www.irsn.fr/vf/09_int/09_int_3_lib/pdf/DOCREF-IRSN2005-48-V1fr.pdf

ties in accident thermal-hydraulics would be jointly organised by the IRSN and BARC to be held in Bombay in the first half of 2006. Furthermore, a seminar on the analysis of the safety of the EPR reactor is also to be organised owing to the interest shown by Indian organisations.

RADIOLOGICAL PROTECTION: STRENGTHENING FRENCH PRESENCE INTERNATIONALLY

In 2005, French representation was boosted at the International Commission for Radiological Protection (ICRP). Five of the seven French members of ICRP are IRSN employees. ICRP's new chairman, Lars-Erik Holm, director of the Swedish institute for radiological protection (SSI), is also a member of the IRSN's scientific council. Several experts from the IRSN also participate in ICRP focus groups.

The IRSN has also stepped up its presence in other international bodies that are competent in the field of radiological protection (Unscear, IAEA, NEA, Euratom, IUR, ISO, IEC, etc.). This trend is linked, in particular, to the greater attention paid to the increased focus on the field of environmental protection and is reflected by the arrival of a new generation of experts. The Institute thus remains one of the main national organisations supplying experts who participate in the work of those bodies.

This active participation is important as the main orientations of the radiological risk management system used to draw up French regulations on radiological protection are the result of consensuses established with international bodies.

Owing to its international position, the IRSN has formed a collaborative group with other French players in the radiological protection field (authorities, industrialists, associations and experts). The last meeting of this group on 2 November 2005 reported on ICRP's process for the revision of its general recommendations and on a project to

modify the Codex Alimentarius provisions regarding the contamination of foodstuffs after a radiological accident.
During this meeting, the IRSN also presented the position statements drawn up by the Institute, or under its supervision, regarding protection of the environment and the European Committee on Radiation Risk (ECRR) *(see Focus below)*.

Controversy over the effects of internal contamination

[FOCUS]

The possible effects on health of chronic internal contamination are a subject of scientific controversy and debate regarding the appropriateness of the current radiological protection system for this type of exposure.
In order to shed light for this debate, the IRSN published a critical analysis report in 2005, regarding the proposals made on this subject by experts participating in ECRR.
The conclusion of this analysis is that ECRR is asking the right questions but that its approach to providing answers is lacking in scientific rigour, making its claims difficult to verify. The IRSN currently considers that there is no need to modify the existing radiological protection system but is stepping up its research efforts in order to answer the questions raised.
For further information, visit: **www.irsn.org/rapport_ecrr**

Contributing to training in radiological protection

Contributing to radiological protection training for health professionals and personnel who are exposed in the course of their work is one of the public service missions assigned to the IRSN. This activity is based on a recent regulation aimed at ensuring that greater account is taken of the risks to which professionals are exposed.

41 sessions organised and completed (20 in 2004)

SUPPORT FOR THE PREVENTION OF RADIOLOGICAL RISKS AND TO LIMIT THEIR CONSEQUENCES

As a research and expert assessment establishment, the IRSN has a duty to provide training and to contribute to teaching in its fields of expertise, i.e. nuclear safety and security as well as radiological protection.

In the course of 2005, the IRSN organised about 40 training sessions on radiological protection in response to needs expressed by an increasingly diversified clientele (industrialists, physicians of radiology, metrologists, etc.), while taking into account the availability of training instructors and the technical means to be implemented. In fact, the sessions were mainly organised by IRSN managerial staff.

These training courses endeavoured to find a compromise between clients' requirements on cost and duration, which are often subject to regulations, and the quest for optimal quality both for the teaching project and for the methods used.

[FOCUS]

Setting up of a training course on the radioactivity of water for engineers and technicians from Ddass and Drass

Training provided by the IRSN.

Over recent years, there have been changes in regulations regarding the radiological quality of water for human consumption, including the order of 12 May 2004 specifying inspection procedures. As a result, the engineers and technicians responsible for the monitoring of "drinking water", within the "health and environment" departments of French departmental and regional administrations for health and social affairs (Ddass and Drass), expressed the need for training in 2005.

In June, 25 Drass and Ddass agents from the Brittany region took part in the first training session on this subject, in Rennes, jointly organised by the DGSNR and the IRSN. This training, which is now available in other regions, aims to provide trainees with the theoretical and practical assessment tools they need to verify that drinking water specifications with regard to radiological criteria are complied with and to inform the local authorities of the steps to be taken if those specifications are not met. The expectations of the administrative departments concerned was gauged during the "trial" training section in Rennes and a training module which can be used for all Ddass and Drass departments was designed.

Training sessions provided in 2005

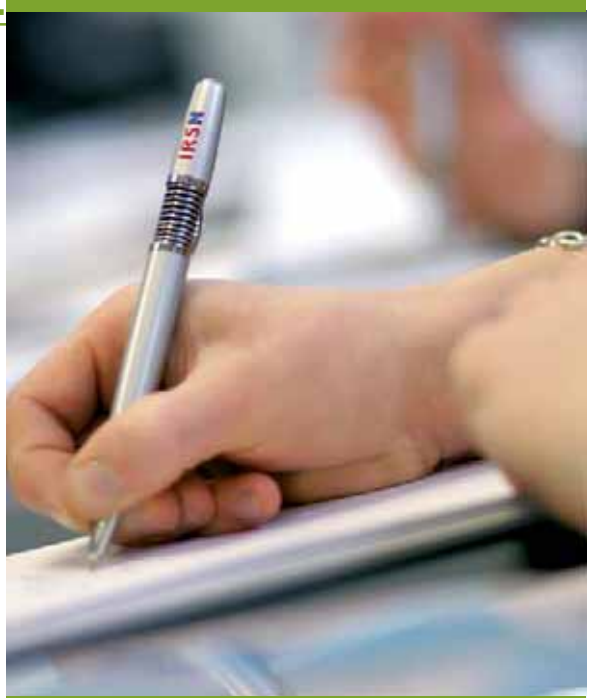
Subject of sessions or professional training activity	Duration of each session	Number of sessions in 2005	Target audience	Number of students trained
Radon metrology	3 days	4	Approved organisations, housing experts	61
Medical radiological protection (patients and workers)	2 days	8	Occupational physicians, personnel skilled in radiological protection	85
Practical training in the assessment of radiological and nuclear risks, and study of exposed work stations	2 days	2	Occupational physicians personnel skilled in radiological protection	16
Assessment of worker exposure to ionising radiation, dosimetry management and SISERI system	2 days	2	Occupational physicians, personnel skilled in radiological protection	20
Dosimetry management at work	2 days	3	Occupational physicians, personnel skilled in radiological protection	20
Training in radiological of exposed workers	1 day	9	Exposed protection personnel	205
Training in radiological protection (radiological protection inspection in the workplace)	3 days	1	Factory inspectors, medical inspectors	25
Training in radiological protection (role, missions and facilities of occupational physicians)	3 days	2	Occupational physicians	38
Raising awareness in a medical environment	1 day	9	Hospital physicians and personnel, occupational physicians, industrial medical officers	95
Radiological protection, citizenship and governance	1 day	1	Elected representatives, members of CLI, teachers	25
Training in radioactivity of water	1 day	1	Engineers from Ddass and Drass	25
TOTAL		**42**		**615**

With the exception of training in radon metrology, which requires a special environment, all other training sessions can be conducted at the IRSN or on clients' premises.

The professional categories that were the most frequently represented in the 2005 sessions were workers exposed to ionising radiation, organisations responsible for measuring radon in establishments opened to the public, physicians of radiology and paramedical personnel working in radiology, occupational physicians and personnel responsible for the dosimetric follow-up of workers, and the factory inspectorate. At the request of the Local Information Commission in Saclay (Essonne), a course on radiological protection, citizenship and governance was arranged for its members (local elected representatives, representatives of associations and teachers).
Some of the courses mentioned above were also attended by IRSN personnel.

[FOCUS]

Professional training programmes offered



Training courses to meet every need.

- Radiological protection of medical and paramedical personnel, for the protection of patients and workers
- Practical training in the assessment of radiological and nuclear risks, and study of exposed work stations
- Radiological protection of exposed personnel in industry
- Assessment of worker exposure to ionising radiation, dosimetry management and SISERI system
- Raising awareness of radiological protection for exposed personnel
- Professional training on the procedures applicable to radioactivity detection portals - Measurement and steps to be taken in case of detection
- Radiological protection and inspection: training for factory inspectors
- Industrial radiology equipment users - Preparation for CAMARI
- Radon metrology in buildings
- Radiological testing of drinking water
- Metrology of drinking water, cross-comparison
- Radiological protection, governance and citizenship

Course provided Course not provided in 2005

Permanent monitoring in the field of radiological protection

In the context of its public service missions, the IRSN carries out permanent monitoring in the field of radiological protection. This includes the monitoring of radioactivity in the environment in France, the assessment of the exposure of personnel and management of the inventory of radiation sources.

RADIOLOGICAL MONITORING OF THE ENVIRONMENT

In France, the monitoring of radioactivity in the environment is ensured by the IRSN using sampling and telemetry stations which may or may not be located close to installations that could discharge radionuclides. The environmental samples taken are analysed in the Institute's approved laboratories.

The telemetry networks provide real-time radiological monitoring of the environment by means of self-contained units that continuously measure the radioactivity of the area where they are located. When an increase in radioactivity is detected, a warning is sent to the IRSN and an investigation is conducted. This was the case in 2005 following a management incident in a nuclear medicine department which led to the release of contents of urine tanks. The Institute's assessment of the corresponding contamination was used to assist in the management of the waste water treatment sludge.

Warning network remote monitoring room in Le Vésinet (Yvelines).

The sampling networks managed by the IRSN are used to monitor changes in radioactivity by analysis of samples of air, water, soil, flora and fauna. 30,000 samples were analysed in 2005. The Institute publishes the results of this monitoring activity on its website and now publishes an annual summary of the radiological state of the environment in France.

Monitoring in French Polynesia

The IRSN conducted a sampling and analysis campaign on foodstuffs produced in French Polynesia, as it does every year. The results are used to determine the exposure of persons living in the various archipelagos. In 2005, the total "added" dose was less than 5 µSv. The annual report on *Radioactivity Monitoring in French Polynesia* published by the IRSN is available on its website.

Metrology to support monitoring

The mission of providing permanent monitoring requires an extremely rigorous approach in laboratories for the analysis of samples. The Institute's

500 sampling points across the country
(500 in 2004)

1,000 gamma radiation measuring points using thermoluminescent detectors
(1,000 in 2004)

213 beacons making up the country's remote monitoring network: Teleray, Hydroteleray, Telehydro and SARA
(213 in 2004)

Nearly **100,000** radiological analyses conducted
(100,000 in 2004)

10,000 source movements

laboratories which perform these measurements are subjected to an approval procedure which testifies to the quality of the results provided (*see the chapter on Quality, part 2*). In 2005, nearly 100,000 measurements were carried out as part of this mission.

Preparing a full inventory of the Institute's measuring capabilities

In order to be prepared for an accident which may require the mobilisation of all its measuring capabilities, the IRSN started drawing up a detailed list of its facilities and organising them into networks. The inventory of environment measuring facilities was completed in 2005.
The laboratories in this "environment" network take part in comparative tests, organised on an internal basis, regarding the identification of the activity of various samples. The results obtained are then analysed to confirm their performance levels and, where applicable, pinpoint areas for improvement. Owing to positive feedback on the operation of this network, it will be extended to all the Institute's measuring laboratories.

FOCUS

Examining the objectives of environmental monitoring

Changes in the industrial context, the partial withdrawal of logistic support for Ddass, technical developments and improvements in knowledge regarding radioecology have led the IRSN to redefine the basis of its mission to monitor radioactivity in the environment and the methods of performing that mission. Four main objectives were identified in an appraisal conducted in 2005:

- monitoring to check for any abnormal situation concerning the warning devices used for the early detection of such a situation;
- observation of environmental compartments to precisely characterise their radioactivity;
- contribution to knowledge regarding radioactive releases, in support of DGSNR in its work to check compliance with regulations in that field;
- supply of information on the state of radioactivity in the environment to ensure an optimal response to statutory requirements and the preoccupation of inhabitants.

The various technical and geographic redeployment operations began in 2005 in order to meet these objectives. A notable result of this activity will be the development of automatic water sampling systems.

PERMANENT MONITORING IN MATTERS OF RADIOLOGICAL PROTECTION

The monitoring missions entrusted to the IRSN in the field of radiological protection concern the management of ionising radiation sources and the assessment of doses received by workers and the public.

Source management

The IRSN manages the national inventory of ionising radiation sources. In this context, the Institute dealt with the following cases in 2005:

- 28 requests to use sources;
- 14 requests for dispensation from CAMARI certification (for the handling of industrial radiography and radioscopy equipment);

SISERI system to centralise dosimetric data on workers.

- 8 enquiries on technical or statutory subjects;
- 10 source inventories for nuclear power plants (CNPE).

Furthermore, 6,700 source user dossiers were managed: 1,900 were modified and more than 10,000 source movements were recorded (procurements, recoveries,imports, exports, etc.).

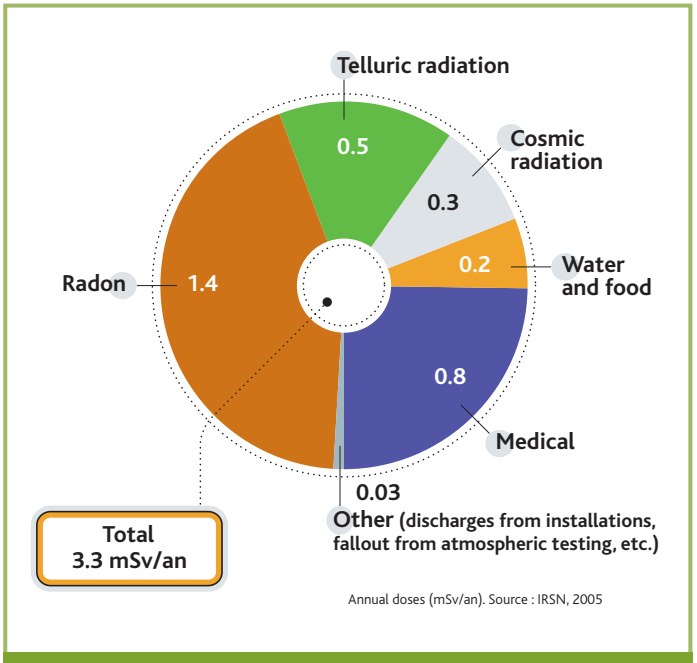
Dosimetric monitoring of workers

In accordance with decree no. 2003-296 of 31 March 2003, the IRSN collects, consolidates and backs up data on the individual dosimetric monitoring of workers exposed to ionising radiation. The dosimetric data, for more than 255,000 active workers, are collected on a monthly or quarterly basis for passive dosimetry and on a day basis for operational dosimetry.
At the request of the Staff relations department, the IRSN set up the SISERI information system to centralise the dosimetric data on French workers.

After a six-month pilot phase, the system was officially commissioned in February 2005. The acquisition of data supplied by the various operators and dosimetry laboratories is conducted in accordance with protocols defined by the Institute. Dosimetric data on individuals can be released to occupational physicians and radiological protection personnel concerned via a secure access system. The operational implementation of the SISERI system will, in time, provide better statistics on professional exposure.

Assessment of exposure levels for members of the public

The mean effective dose received in France from ionising radiation sources was reviewed by the IRSN in 2005. The new estimate takes into account the average dose corresponding to medical exposures, which is now estimated to be 0.8 mSv per person per year.
All in all, the mean effective dose received in France is 3.3 mSv per person per year. This value is very close to the world average figure of 3.4 mSv/year lited by Unscear.



Distribution of the exposure to ionising radiation for the population of France.

Contributing to public information and transparency

Teaching and transparency are two principles governing the IRSN's actions with society. The Institute therefore makes a point of including nuclear and radiological risks as part of the overall picture for all industrial risks. At the same time, through its range of activities, it places its expertise at the service of professionals (in fields including medicine, nuclear safety and the environment) and the public.

PUBLIC INFORMATION

Public information, which is laid down as one of the IRSN's missions in its decree of creation is aimed at making the state of knowledge and expertise in the field of nuclear and radiological risks as widely accessible as possible. In this spirit, the Institute continued in 2005 with its policy of publishing for various categories of the public, the organisation of exhibitions and its participation in fairs and events, as well as making a special effort to develop its web portal.

"Nuclear under close surveillance" road show

3,360 visitors (6,500 in 2004) including 340 school pupils (1,120 in 2004)
2 cities visited (4 in 2004)

5 conferences organised (15 in 2004)

831 requests for information processed via the contact box on the website (778 in 2004)

14,000 copies of the annual report distributed (12,000 in 2004)

Participation in 5 professional exhibitions and public events (5 in 2004)

Direct information

As a nuclear and radiological risk expert for the benefit of society, the IRSN organises and participates in events enabling it to come into contact with the public. In 2005, the Institute updated the ASN/IRSN road show, known as "Nuclear under close surveillance " with modified Chernobyl, Environment and Health modules. This exhibition, featuring round tables and conferences, attracted 2,000 visitors in Evry (Essonne) and 1,100 visitors in Bourges (Cher).

In addition, the IRSN set up a teaching area which welcomed 10,000 visitors at the 1st European Research and Innovation exhibition. At the Festival of Science organised by the French Ministry of

Well-earned success for the road show in Bourges (Cher).

Research, the Institute organised a stand in the Luxemburg Gardens in Paris and supervised a science bar focusing on the topic of risk perception.

Inauguration of the AMANDE and EPICUR installations in March 2005, in Cadarache (Bouches-du-Rhône).

Information through the media

The IRSN took steps, in 2005, to optimise its responsiveness to requests from the media and to invite journalists to events such as visiting two of its new installations (AMANDE and EPICUR) and press conferences including, in particular, those concerning the publication of its 2005 barometer and reporting on the Franco-German initiative on the consequences of the Chernobyl accident.

As a result of this effort, the number of articles published mentioning the IRSN increased by more than 45% (making a total of 220 articles published in 2005 compared with 150 the previous year). The topics attracting the greatest media coverage during this period included the safety of nuclear installations, the environment and transparency.

Information for professionals

The IRSN organised information areas at various trade fairs and congresses last year: at Pollutec, an international exhibition of equipment, technologies and services for the environment (Paris), the Institute received nearly 4,000 visitors on its stand built around three topics: presentation of the Institute; expert assessments and services; contracts.

At the Medec professional health exhibition (Paris), the IRSN welcomed about 1,000 visitors.

The Institute also participated, for the first time, in the 11th Nureth congress attended by specialists in nuclear reactor thermal-hydraulics in Avignon (Vaucluse).

With its Belgian and German counterparts, AVN and GRS, the IRSN jointly organised the EUROSAFE forum in Brussels (Belgium) on 7 and 8 November 2005. For the occasion, the forum focused on improving safety: foundations, strategies and deployment. This forum also has a twice-yearly publication, *the EUROSAFE Tribune*, and a website: **www.eurosafe-forum.org**.

The IRSN's web portal

The IRSN's web portal (**www.irsn.org**) attracted an increasing number of hits (+ 25.5%), rising from 689,038 sessions in 2004 to 864,896 in 2005. Last year, the Institute restructured this portal (which features about 3,000 pages in French and 500 in English) to improve its accessibility for the public, the press and professionals concerned by the Institute's fields of activity.

In this context, the following websites came on line: **www.irsn.org/eau** (concerning the monitoring of radioactivity in water, sludge and sediments) and **www.irsn.org/formations** (covering the whole IRSN range in the field of training).

The new portal has new features, such as a newsletter, a download centre and the synchronisation of data between all the Institute's internet and intranet sites.

24,500
information booklets distributed (30,000 in 2004) **and 22,150 brochures on the Institute's training activities and services distributed** (4,500 in 2004)

868,000
hits in 2005 (690,000 in 2004), **including 250,000 single visitors** (195,000 in 2004) **on the Institute's website: www.irsn.org**

76,966
hits (55,548 in 2004), **including some 3,262 single visitors per month** (2,000 in 2004), **on the IRSN's scientific website**

Mrs Nelly OLIN, Minister for Ecology and Sustainable Development visiting the IRSN stand at Pollutec in December 2005.

[FOCUS]

Pilot project with CLIs concerning radioactivity in the environment in the Loire basin

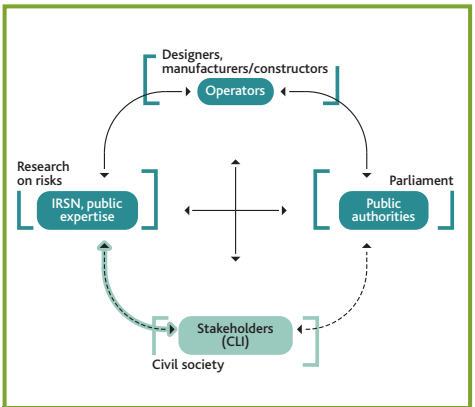
The site at Saint-Laurent-des-Eaux. The first CLI was mobilised to set up the pilot project conducted in the Loire basin.

Along with the CLIs of the Loire basin, the IRSN started a project on the utilisation and intelligibility, for local actors, of measurements of radioactivity in their environment. The purpose of this project is to create environment follow-up tools on the basis of the measurements carried out by the IRSN and, more generally, those that will be available in the context of the national network to measure radioactivity in the environment.
After explaining this approach to CLIs, the IRSN held discussions with them and, on that basis, it was able to identify their exact expectations. Future discussions will be held to ascertain the expectations of CLIs for the whole Loire basin and, subsequently, on the national level with Ancli.

OPENING UP EXPERTISE FOR SOCIETY

In 2005, the opening-up of the IRSN's expertise for society resulted in various types of actions involving associations, unions representatives and other expert institutes. Above and beyond the pilot projects which may lead to the forming of pluralist expert groups in order to deal with complex or controversial subjects, the IRSN's commitment is reflected by its participation in networks for information, optimisation and feedback, and the creation of such networks.

In the context of the protocol signed with the IRSN in 2003, the French National Association for Local Information Commissions (Ancli) called upon the IRSN, in 2005, for assistance with the governance of nuclear waste management.
The project includes two parts: the preparation of a seminar on "international feedback on participative governance for nuclear waste management" and follow-up of the public debate on radioactive waste management to consider the emergence of innovative processes allowing society to become involved.
For the IRSN, this means contributing to the development of a culture of participative governance



Nuclear safety depends on the vigilance of four parties: the operator, the public authority, the public expert and the stakeholders in civil society.

in its own organisation and making its work in the field of radioactive waste and its governance accessible to civil society. Furthermore, the IRSN has started a collaboration with unions representatives on the monitoring of the exposure of workers to ionising radiation. This entails a mission conducted by the Institute for the benefit of workers and public authorities as well as to the stakeholders, employers and trade unions.

In addition, the IRSN is examining developments in the governance of hazardous activities and situations along with five national expert institutes (Afsset, Ineris, Inrets, INRS, InVS).
For the Institute, the aim of this co-operation is to place its approach in perspective with those of other public institutes and to join them in strategic discussions which could lead to joint action and to exchanges on these new modes of governance.

[FOCUS]

The IRSN's participation in the public debate on the first-off EPR project in Flamanville

The safety of the EPR project is assessed by the IRSN.

The IRSN was mobilised to provide clearly understandable information for the Special Commission for Public Debate (CPDP) and to members of the public taking part in the debate which started in mid-October 2005. In the participant's guide drawn up for this occasion, the IRSN summarises the general safety aims adopted for EPR type nuclear power reactors.
The Institute emphasises certain important points of its assessment of the safety of the EPR project and points out that it worked in co-operation with the Group of Scientists for Information on Nuclear Energy (GSIEN) and Ancli on this matter and that it is ready to continue work in that vein.

Key figures 2005

Key figures 2004

9 national nuclear crisis exercises

9

2 real actions taken by the CTC

2

25 meetings held by the standing advisory groups

24

TECHNICAL SUPPORT AND ASSISTANCE FOR PUBLIC AUTHORITIES

Whether they act for the authority (technical assistance) or as technical support, the IRSN conducts its activities in partnership with the public authorities.

In order to advance in the quality of its expertise, the IRSN conducts a technical dialogue with industrialists and formalizes its technical doctrine by the publication of documents.

Technical support with regard to nuclear and radiological risk

Operational support in the event of a crisis or radiological emergency

Technical support with regard to nuclear and radiological risk

The technical support provided by the IRSN to the authorities consists of expert assessment of technical files submitted by industrialists. These files concern the safety of reactors, fuel cycle plants, transport and dismantling, as well as radioactive waste management. They also concern protection of man and the environment. Following these expert assessments, the IRSN puts forward recommendations on the arrangements proposed by the industrialists and the medical sector to control these risks. These recommendations are sent to the authorities or presented to the competent Standing advisory group of experts.

SAFETY ANALYSIS OF NUCLEAR REACTORS

The IRSN provides technical support to the DGSNR[5] as regards the safety assessment and radiological protection in the 58 reactors in operation on the French nuclear power plants. It also assesses the safety of experimental reactors and that of the EPR reactor. In 2005, the Institute worked hard to review the safety of 1,300 MWe reactors with a view to their second 10-yearly outage programmes, and that of the 900 MWe reactors with a view to their third 10-yearly outage programmes.

Reactor safety reviews and associated safety reports

Each reactor in operation undergoes a safety review every 10 years. This review includes checking that the power plants remain in conformity with their design and operation standards, and studying any possible changes to these standards and the associated modifications. These modifications aim at improving the safety of the reactors. They are based on feedback, advances in knowledge and new safety provisions adopted for the most recent reactors whenever that is technically feasible and there is a significant gain in terms of safety. During the year 2005, the IRSN continued its review of 900 MWe reactor safety with a view to their third 10-yearly outage programmes (VD3 900) *(see Focus opposite)*. Finally, as regards the second 10-yearly outage programmes for the 1,300 MWe reactors, the Institute completed the examination of safety review studies, modifications and the standard safety report.

688 technical reports to the public authorities excluding defence-related activities (608 in 2004)

630 participations in inspections of basic nuclear installations (almost 600 in 2004)

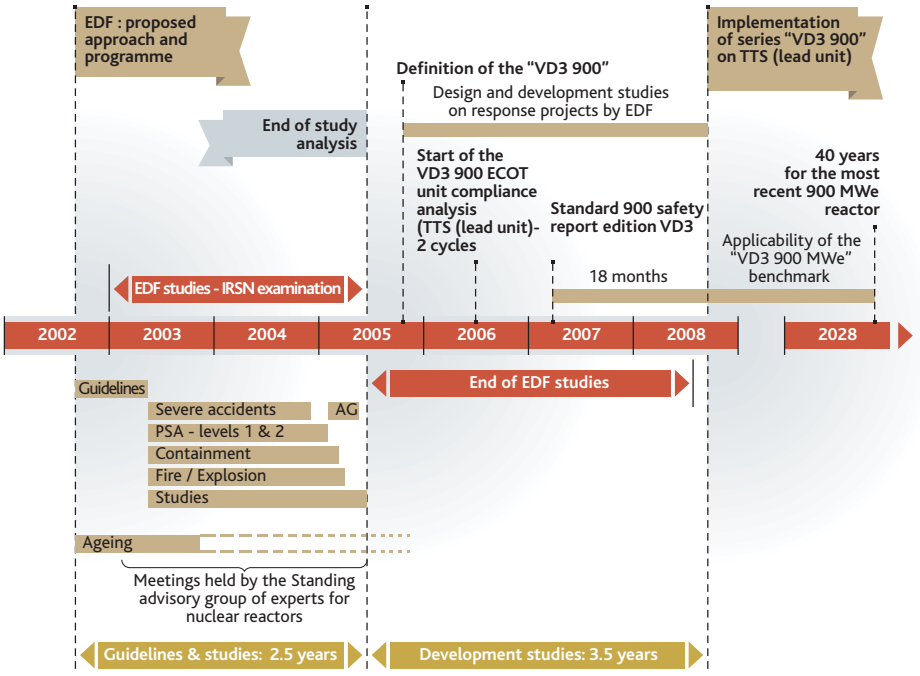
143 test reports regarding cross-comparison exercises of environmental radioactivity measurements (107 in 2004)

110 recommendations for radiological protection of man (134 in 2004)

The safety report is used as a basis for the review.

(5) DGSNR: General department for nuclear safety and radiological protection.

Safety review associated with the third 10-yearly outage programmes of 900 MWe reactors



The schedule of the safety review associated with the third 10-yearly outage programmes of 900 MWe reactors.

In early 2005, the IRSN completed the main investigation phase of the safety review studies associated with the third 10-yearly outage programmes for 900 MWe reactors (VD3 900). This ended with seven meetings of the Standing advisory group of experts for nuclear reactors.
These studies consisted in checking conformity of the 34 900 MWe reactors to the applicable safety requirements and reassessing these requirements in the light of feedback and changing technical knowledge. These studies mainly concerned:

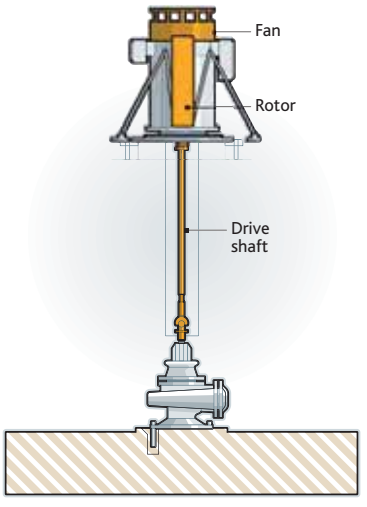
- probabilistic safety assessments (PSA) quantifying the risks of core meltdown and release of radioactive products;
- internal hazards in the installations such as fire (which gave rise to a specific PSA in the IRSN) and explosion;
- climatic hazards which may affect all safety functions on a site;
- earthquake resistance of the installations;
- design of many items of equipment, such as the security injection circuit, containment, the spent fuel storage pits and their cooling systems;
- severe accidents.

This work has led to around 20 modifications which will be implemented during the next 10-yearly outage programmes (from 2009) to guarantee and improve the safety of 900 MWe reactors.

Examination of programmes of work and inspections carried out during refuelling shutdowns and reactor maintenance

In 2005, 52 planned shutdowns lasting from three weeks to three months were examined by the IRSN. In each case, the Institute studied the work and inspection programmes planned by the operator, monitored the performance of these operations, examined the handling of deviations identified and the results of restarting tests.

In particular, the IRSN examined the actions decided by EDF to deal with the generic anomaly affecting motor pump units in some backup circuits of the 34 900 MWe reactors. This incident was reported as class-2 significant event on the INES scale in December 2005.



Details concerning the anomaly on the motor pump units were published on the IRSN website.

[FOCUS]

Risk of spent fuel pit drainage

In 2005, as part of the safety review associated with the third 10-yearly outage programmes for 900 MWe reactors, the IRSN showed that some accident sequences could lead to a rapid drainage of the spent fuel pit. The examination of feedback also revealed that many precursor events had occurred and that some had already led to considerable draining.
As well as the total loss of cooling of the stored fuel, one of the possible consequences of these events would be the partial or total dewatering of one or several assemblies during handling *(see Focus "Spent fuel pit drainage accident"*)*.
The IRSN analysis led EDF to implement provisions to strengthen prevention on all nuclear power plant reactors in the installed base from 2006 and to facilitate management of such an accident situation.
In the medium-term, other modifications will be implemented on the 900 MWe reactors during the third 10-yearly outage programmes, the first of which will take place in 2009.
In particular, they concern rapid isolation of the reactor's spent fuel pit in the event of draining, removal to a safe position of an assembly during handling and monitoring of the pit level from the control room.

FOCUS p.54

Examination of general operating rules (GOR)

GORs are used to ensure compliance during operation of the limitations fixed on design. These rules should evolve according to the modifications made to the reactors and to feedback.

In 2005, the IRSN sent more than 100 recommendations on the acceptability, from the safety point of view, of the evolutions proposed by EDF or occasional concessions to the GOR requested following operating contingencies. The Institute examined the file regarding the restarting of reactors in the event of a generalised loss of the electricity network; its recommendation led EDF to modify its proposals.

Analysis of reactor operation experience feedback

The IRSN examines the feedback from reactor operation, in particular the events and anomalies affecting them.
The 760 significant events reported by EDF in 2005 were examined and described in an IRSN computer database. The most characteristic incidents of safety failings were or will be subjected to thorough analysis, and in some cases considered to be precursors, probablistic studies will be

conducted to assess their severity in terms of risk of damage to the reactor core. Furthermore, the IRSN sends reports on the most significant incidents to the IAEA, in accordance with the terms of the international Incident Reporting System.
In order to obtain an overall appreciation of operating safety evolutions in the power plants, the IRSN has developed a statistical events analysis tool enabling indicators to be drawn up. These tools were used in 2005 to conduct a statistical analysis of the incidents occurred between 2000 and 2002. This work will be completed based on statistical data regarding events occurred from 1997 to 1999 and from 2003 to 2005.

Monitoring inspections

In 2005, the IRSN supported basic nuclear installation inspectors in the preparation of nearly 300 monitoring inspections on EDF reactors. The IRSN accompanied the inspectors for some of those inspections.

Protection of reactors against external hazards

In 2005, the IRSN continued examining the protection of nuclear power plants against external hazards. In particular, it examined the autonomy of reactors and sites against natural hazards which may simultaneously affect several reactors. In addition, the Institute analysed the doctrine proposed by EDF against the risks of oil spills and flooding.

Moreover, in an international working group, the IRSN participated in the review of IAEA guidelines on the protection against risks of flooding.

The IRSN analyses the dossiers sent by EDF.

Incident in Nogent-sur-Seine [FOCUS]

On 30 September 2005, when reactor no. 1 in the Nogent-sur-Seine (Aube) power plant was restarting following a refuelling shutdown, successive human and material failures led to a spill of hot water from the secondary circuit in the "electrical" building. Untimely orders caused automatic shutdown of the reactor and starting of the safety injection system. In addition, the sudden appearance of a "high neutron flow" alarm caused the triggering of the internal emergency plan and the implementation of the national crisis organisation.
The IRSN's Technical Crisis Centre was thus activated from 9 am to 3.15 pm and on 3 October 2005, the Institute participated in an inspection of the damaged areas. The IRSN then launched an in-depth analysis of this severe incident. If the consequences of the leaks had been more serious, the failure of other electrical switchboards which remained operational on 30 September, could have made control more delicate. During the meeting of 7 December 2005, the IRSN presented its opinion to the members of the Local Information Commission (CLI).

Safety assessment of the EPR nuclear reactor project

Since the drawing up of Technical Guidelines in October 2000, and pending a request for authorisation for an EPR-type reactor in France, the IRSN has continued to examine the safety of this reactor project based on technical dossiers which:
- deal with compliance with general safety objectives;
- concern innovative technical solutions;
- concern provisions which have evolved since the technical guidelines were drawn up;
- describe the evolutions implemented in the reactors in operation.

During the year 2005, a set of technical dossiers was thus examined by the IRSN, and was presented and discussed during meetings of the Standing advisory group for nuclear reactors. These files concern:
- radiological protection of workers in normal operation;
- qualification of equipment to accident conditions;
- "failure prevention" for the main steam pipes;
- "practical elimination" of core meltdown situations with containment by-pass;

- safety requirements for the design of civil engineering works;
- design provisions regarding heat-wave situations;
- dealing with a significant breach in the cooling circuit during shutdown;
- architecture of command-control systems;
- the design of the shutdown station, the pumping station and the corium recovery system;
- principles of the preventive maintenance performed with the reactor in power operation.

In addition, the Institute participated in drawing up several technical assessment reports presented to the permanent nuclear section of the Central committee for pressure vessels. These reports deal with the examination of design choices for some major components such as steam generators, etc.

In 2005, recommendations were made by the IRSN on the EPR safety standard and on assessment methods for radiological consequences in accident situations.

Follow up experimental reactors

The IRSN carries out safety expert assessments on research reactors and the PHENIX fast-neutron reactor operated by the CEA and the high-flux reactor (RHF) in Grenoble (Isère), operated by the Laue-Langevin Institute.
In 2005, the Institute's expert assessment work mainly concerned the MASURCA reactor, in Cadarache (Bouches-du-Rhône), for which a safety review is in progress. The IRSN examined the review procedure selected by the CEA and studied the relevance of orientations regarding modifications

Bottom view of the MASURCA reactor, during insertion of fuel rods.

to the plant planned by the operator as part of renovation work. Moreover, the IRSN examined the application for authorisation to install a core representative of the fast-neutron, gas-cooled reactors; these reactors are being studied within the framework of the international R&D forum "Generation IV" dedicated to studying reactors of the future.

In addition, the IRSN issued recommendations concerning the disposal of irradiated fuel elements from the OSIRIS reactor in Saclay (Essonne), and the IRIS TÜM experimental radiation.
In 2005, the Institute analysed the incidents which

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Seminar in China on the EPR reactor project

In March 2005, a seminar was held in Beijing on the EPR project. Organised jointly by the DGSNR and the IRSN, the aim of this seminar was to present the safety options and design principles of the EPR reactor project to the Chinese safety authority NNSA, and its technical support.
At the NNSA's request, this seminar was held before the Chinese authorities conduct an assessment of the proposals submitted by the various constructors in reply to the call for tender issued by China to build 3rd-generation reactors.
During the seminar, the participants from the DGSNR and the IRSN presented the project's assessment approach and shared their experience of the safety assessment, with their Chinese counterparts, on major design issues.

Standing advisory group for nuclear reactors

Object	Date of meeting
Examination of commissioning of the two Civaux reactors	20/01/2005
Examination of the results of level 1 and 2 probabilistic safety assessments for 900 MWe reactors	03/02/2005 10/02/2005
Examination of the containment behaviour of 900 MWe reactors	03/03/2005
Examination of the improvement of knowledge on the risks of fire and protection of installations against explosions which may occur on a site	10/03/2005
Conclusion of studies of the safety assessment associated with the third 10-yearly outage programmes for 900 MWe reactors "VD3 90"	24/03/2005 31/03/2005 21/04/2005
Examination of operating experience from French and foreign pressurised water reactors during the period 2000 to 2002 (2nd session)	16/06/2005
Continuation of the safety assessment of the EPR reactor project (3rd meeting) in particular concerning radiological protection, risk of bypassing containment and equipment qualification	05/07/2005
Human and organisational factors awareness day	20/10/2005
Continuation of the safety assessment of the EPR reactor project (4th meeting) in particular concerning control and instrumentation, corium recovery system, the principles of preventive maintenance	01/12/2005
Safety review associated with the second 10-yearly outage programmes of 1,300 MWe reactors	22/12/2005

have occurred in the PHENIX plant in Marcoule (Gard), since its restarting in 2003, in particular those regarding safety threshold rules. In general, these incidents revealed a lack of experience due to renewal of the teams.
The IRSN sent a recommendation on draft technical design guidelines for the experimental devices in the CEA reactors in general. It also examined the methods for reporting "significant" events and the documents regarding safety reviews.

The PHENIX reactor is being monitored by the IRSN.

SUPPORT FOR THE SAFETY ANALYSIS OF REACTORS IN OPERATION

In 2005, the IRSN continued its activities in support of the safety analysis of reactors in operation, in particular in the fields of civil engineering, probabilistic safety assessments and thermal-hydraulics. The Institute also helped to prepare meetings of the permanent nuclear section of the Central committee for pressure vessels.

Civil engineering

In 2005, the IRSN continued the review of the seismic behaviour of civil engineering structures:
- for the 900 MWe power plants in Fessenheim (Haut-Rhin) and Bugey (Ain);
- for electrical buildings and machine rooms in 1,300 MWe power plants.

For the EPR project, the Institute examined the requirements retained by EDF for the design basis civil engineering works and the design principles of the equipment access hatch in the reactor building. Finally, the IRSN examined the project to revise the basic safety rules regarding aseismic design of nuclear power plants, with a view to presenting it to the standing advisory groups in early of 2006.

Preparation of meetings of the Permanent nuclear section (SPN) of the Central committee for pressure vessels (CCAP)

The SPN held seven meetings during 2005. Within this framework, the IRSN contributed to the investigation and to the reports concerning:
- the design of some components in the EPR reactor project (such as control rod drive mechanisms or steam generators);
- the conditions to be associated with the implementation of the failure prevention hypothesis for the design of the EPR reactor project;
- regulatory reference dossiers regarding the main secondary circuits in pressurized water reactors;
- ageing under irradiation of 900 MWe reactor vessels.

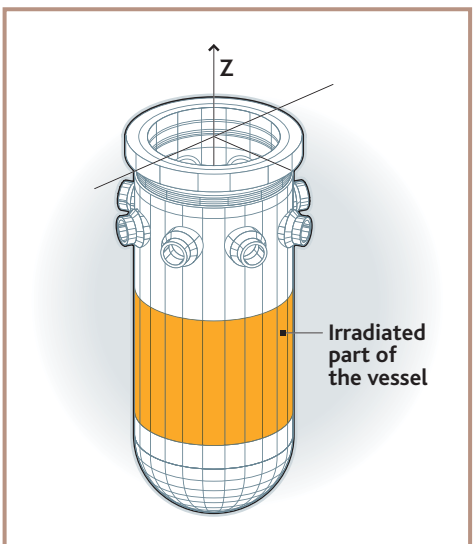
Level 1 probabilistic safety assessments

Probabilistic safety assessments (PSA) contribute to understanding the arrangements adopted by the operators. In particular, they enable problems identified during the design or operation of plants to be better prioritized, and hence to define the most urgent improvements to be made.

The lessons learnt from level 1 PSA on 900 MWe reactors were used in 2005 during the safety review on the VD3 900 and may lead EDF to add to the modifications associated with this review. A revision of the level 1 PSA review for 900 MWe reactors is in progress at the IRSN to take account of the follow-ups to this review and to obtain a representative study of the condition of the plants following their third 10-yearly outage programmes.

Thermal-hydraulics

In support of the safety analysis of pressurised water reactors, the IRSN is conducting studies using thermal-hydraulic software.
In 2005, in collaboration with the Finnish safety authority STUK, the Institute carried out calculations regarding the steam generator tube rupture accident, to assess the differences in accident management, between the Finnish EPR nuclear reactor project and the French EPR nuclear reactor project.



Irradiation makes the reactor vessels fragile.

PROBABILISTIC SAFETY ASSESSMENTS (PSA)

PSAs consist of a systematic investigation of accident scenarios.
- Level 1 PSA identifies the scenarios which may lead to a core meltdown and determines their frequencies.
- Fire PSA deals with the risks associated with fire.
- The level 2 PSA can be used to evaluate the nature, extent and frequency of radioactive discharges outside the containment.

In order to prepare the analysis of future EDF studies, the IRSN initiated expert assessments of the latest version of the CATHARE software in 2005 and appraisal of the associated uncertainties (participation in the OECD BEMUSE project). The Institute also continued studies into steam pipe break accidents.

The lessons learnt from the level 1 PSA for 900 MWe reactors were used during the safety review associated with the VD3 900.

Radiological consequences of accidents

[FOCUS]

Assessment of radiological consequences: a major study for the environment around nuclear power plants.

The radiological consequences of accidents were until now calculated according to two different methods, one French for reactors in operation, the other German for the EPR reactor project. EDF wishes to harmonise these two methods and use the common method mainly derived from the French one, in particular for the provisional safety report on the EPR reactor project.
During 2005, the IRSN first examined the principles adopted by EDF in view of this harmonisation. The Institute also studied the approach chosen to carry out awareness studies presented in the preliminary safety report for the EPR reactor project for all accident operating conditions. The aim of these studies is to evaluate the impact of the chosen method on the results.
The IRSN then started to analyse the new assessment standard for radiological consequences, which covers both the assessment of the activity released outside the containment and the dosimetric impact on man and the environment. The Institute will present its conclusions (excluding core meltdown situations) in 2006.

Nuclear auxiliary building control room.

AGEING OF PRESSURISED WATER REACTORS (PWR)

In line with the meeting of the Standing advisory group for nuclear reactors, regarding the method adopted by EDF to control PWR ageing, the IRSN conducted in 2005 the following additional studies:

- examination of the relevance of R&D programmes and the means implemented by EDF to take account of the ageing of 900 MWe reactors beyond the 10-yearly outage programme;
- suitability of monitoring methods for ageing of active components to demonstrate maintenance of their reliability and their qualification to accident conditions;
- exhaustivity, quality and suitability of ageing analysis sheets used by the operator.

The aim of these sheets, for each item of equipment, is to show control of ageing given the knowledge and in-service test programmes planned.

HUMAN AND ORGANISATIONAL RELIABILITY

2005 was marked by the continuing development of the IRSN's expert assessment activities in the field of human and organisational reliability.

In-depth analysis of events

Five significant safety events which occurred in nuclear power plants were examined. The IRSN reconstructed precise timelines of the actions carried out by the operators, in parallel with the evolutions of the installation's parameters. The Institute examined the relevance of the corrective measures implemented by EDF to prevent such events from reoccurring. It recommended that EDF strengthens its provisions intended to ensure the quality of activity planning and preparation phases. It was also able to confirm the central role played by communication between the actors in detecting and recovering from errors.

Operation feedback

During the meeting of the Standing advisory group in June 2005 devoted to examining the operation feedback from EDF nuclear power plants, three subjects concerning human and organisational reliability were examined:

- the action plan implemented by EDF to improve interventions which may lead to failures of electrical switchboards and to improve operating procedures to be applied to limit the consequences of such failures;
- the risk analysis approach implemented by EDF to improve the preparation of interventions;
- the ability of the operating manager and the safety engineer to ensure, in coordination, their missions in the field of safety.

Skills management

The IRSN examined the arrangements made by EDF as part of its skills management policy and its implementation on the sites. Unlike training policy, the skills management policy gives a central place to identifying the needs of the agents closest to the field and enables skills needs to be anticipated.

FUEL BEHAVIOUR IN NORMAL AND ACCIDENT OPERATING CONDITIONS

The IRSN provides the DGSNR with technical support for the study of fuel management provisions proposed by EDF and, in particular, management changes planned by the operator by 2007.

As part of fuel management changes, the IRSN examined in 2005 the feasibility of the ALCADE fuel management system planned for 1,450 MWe reactors. The goal of EDF is to operate these reactors in cycles of 17 to 18 months instead of the current 10 to 12 months. In its analysis, the IRSN in particular brought to light:

- reactor vessel modelling issues, in the thermal-hydraulic code (CATHARE) used to evaluate the fuel cladding temperature, during a loss of coolant accident.
- insufficiencies regarding the demonstration of the conservatism of the study methods of the rod ejection accident using 3D modelling;
- lack of representativity of the tests required at defining the criteria to be used for the study of the interaction between pellets and cladding;
- yet insufficient feedback concerning the behaviour, in normal operating conditions, of the new fuel assembly structure AFA-3GLr-AA in M5 alloy.

ALCADE management safety studies will be examined in 2006 and a special meeting of the Standing advisory group for nuclear reactors will be held on this subject.

ALCADE MANAGEMENT

This differs from current management:
- an increase in the enrichment of uranium 235 from fissile matter from 3.4% to 4%;
- an increase in the maximum discharge burnup rate of fuel rods from 48 GWj/t to 52 GWj/t;
- renewal of the fuel by one third of the core instead of by one quarter of the core;
- implementation of modified loading plans to reduce the neutron flow on the vessel.

Compared to current management, ALCADE management specifically means an increase in the power differences in the core.

EXAMINATION OF RISKS ASSOCIATED WITH SEVERE REACTOR CORE MELTDOWN ACCIDENTS

The risks associated with severe core meltdown accidents are continuously examined by the Institute. This examination is supported by research and development programmes and regular meetings of the Standing advisory group of experts for nuclear reactors are held.

In 2005, the analysis of these risks was continued as part of the safety review associated with the third 10-yearly outage programmes for 900 MWe reactors. In particular, during two meetings of the Standing advisory group of experts for nuclear reactors (GPR), the lessons to be learnt from the level 2 PSA *(see Focus*)*, and the "severe accidents" standard *(see Focus*)* proposed by EDF . In addition, as regards the EPR reactor project, the IRSN continued to examine the robustness of the corium recovery concept proposed by EDF. It also examined the instrumentation provided to monitor the progress of a severe accident.

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*FOCUS p.110

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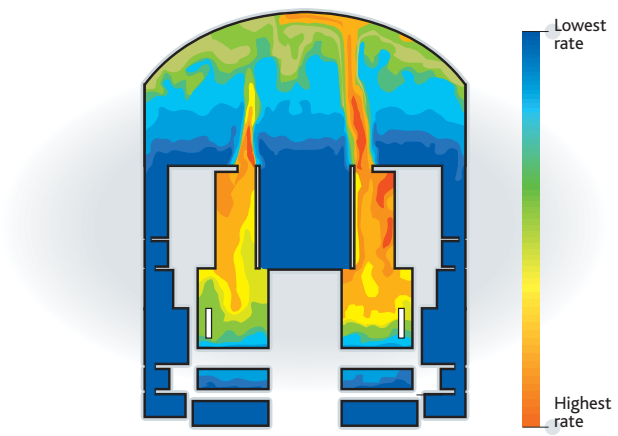
"Severe accidents" standard



Calculations of the distribution of steam and hydrogen inside the reactor containment during a severe accident.

In 2005, the IRSN examined the "severe accidents" standard proposed by EDF for its reactors in operation. This standard aims at defining:

- the approach and objectives sought by EDF in terms of preventing and limiting the consequences of severe accidents;
- the studies required to demonstrate that these objectives are being followed;
- the practical provisions retained and their sizing bases.

In order to analyse this standard, the IRSN used the conclusions of previous GPR meetings to examine the risks associated with severe accidents, and the studies conducted to support its level 2 PSA. Following this assessment, the Institute put forward strong reserves as to the probabilistic objectives proposed by EDF. It also underlined that, in its current state, the standard presented a large number of issues still under investigation.
On this occasion, the IRSN also examined the new pressure and temperature profile inside the containment proposed by EDF to check the behaviour of the equipment in a severe accident situation. The IRSN considered that EDF needed to complete the list of scenarios chosen to define this profile.

FOURTH GENERATION REACTORS

In 2005, the IRSN signed collaboration agreements concerning fourth generation reactors.

2005 saw the concrete signing of the Areva/IRSN protocol governing exchanges on safety issues associated with the Antares project (a very-high temperature, graphite-moderated and helium-cooled reactor project). The Institute drew up a summary of the safety approach developed for French graphite-gas reactors and the associated feedback. The lessons learnt from this work will be used within the framework of the exchange group on the Antares project. In addition, the IRSN became a partner in the integrated European RAPHAEL project, which is developing research and development work to support in the design of high-temperature reactors.
At the same time, the IRSN made an initial comparison of the safety principles of six nuclear systems chosen by the international "Generation IV" forum.

The FIG IV: an international initiative to develop the next generation of nuclear systems.

SAFETY OF PLANTS, TRANSPORT AND DISMANTLING

The IRSN provides the expert assessments of technical dossiers transmitted by nuclear installation operators and by applicants for radioactive material transport packages. The Institute also studies the risks of dispersion of radioactive materials and criticality present in most installations and during transport. The IRSN draws up reports on internal emergency plans (PUI) for sites containing nuclear installations.

Installations upstream of cycle

Areva is planning to build a new uranium enrichment plant (George Besse II facility) on the Pierrelatte site (Drôme), which will use the enrichment process by centrifugation. This process enables the quantity of gaseous UF_6 present in the installation to be significantly reduced. In 2005, the IRSN examined the preliminary safety report for this new installation and presented its recommendation to the competent Standing advisory group. Significant improvements in terms of reducing exposure to ionising radiation, limiting the risks of fire and resistance to external hazards have already been made by the operator following these exchanges with the Institute during the investigation of this issue.

For its part, FBFC is planning to increase the production capacities in its fuel assembly production plant in Romans-sur-Isère (Drôme). The IRSN examined the safety report for this project, which aims to raise the plant's annual capacity from 1,200 to 1,800 tonnes for the manufacture of uranium oxide powder in the conversion workshop, and from 820 to 1,400 tonnes for the manufacture of fuel assemblies. Following its expert assessment, the IRSN presented its recommendation to the competent Standing advisory group, which concluded that the capacity increases requested by the operator were possible within acceptable safety conditions, in particular given the planned renovation of the industrial plant. Moreover, the IRSN formulated recommendations regarding the cleaning operations of the plutonium technology workshop (ATPu) in Cadarache (Bouches-du-Rhône).

[FOCUS] Using the level 2 PSA in safety analysis

Home page of the user-friendly PSA 2 application.

The level 2 PSA is used to assess the frequency, extent and moment of appearance of discharges into the environment during core meltdown scenarios identified in the level 1 PSA. During 2005, the IRSN continued to update the level 2 PSA it is conducting for 900 MWe reactors. The aim by the end of 2006 is to avail of a version which takes account of all accident initiators from the level 1 PSA and the "events" management.
The IRSN also started preliminary work to carry out a level 2 PSA for 1,300 MWe reactors.

On the occasion of the safety review associated with the VD3 900, for the first time EDF presented a level 2 PSA, conducted in order to prioritize the risks associated with severe accidents and to evaluate the interest of possible modifications to the design or operation of the reactors.
To examine this study and the lessons learnt by EDF, the IRSN based itself largely on its own level 2 PSA. The Institute put forward recommendations to improve EDF's study and its approach to use. Lessons have nevertheless already been learnt for the VD3 900. In particular, the operator has been asked to study the interest and feasibility of provisions enabling discharges of iodine to be limited in the event the draining-filtration device in the containment is opened.

Installations "downstream" of cycle

■ Irradiated fuel reprocessing installations

For installations downstream of the fuel cycle, a major portion of the IRSN's work was devoted to examining changes in the operating ranges of irradiated fuel reprocessing installations UP2-800 and UP3-A in La Hague (Manche). Four specific dossiers were examined by the Institute in 2005 which led to the publication of four interministerial decrees. In particular, the IRSN examined changes in the risks related to heat releases and radiolysis, risks of external exposure and criticality risks and the provisions made by the operator to protect workers and the environment.

In 2005, the IRSN also investigated a dossier regarding the waste management policy at the La Hague site. The Institute estimated that the plant's means and the changes in the short- and medium-term appear globally coherent with the strategy proposed to process, package and store waste related to programmes that the plant is planning to implement over the coming years.

The IRSN gave its opinion on the safety of recovery operations for "old" radioactive sludge planned by the operator. This sludge comes from waste treatment produced by the UP2-400 plant, currently shutdown. The operator is planning to hot precoat it with bitumen within the STE3 plant. The main risks examined by the Institute were risks of fire and explosion due to the reactivity of the chemical species coated. This expert assessment was based in particular on feedback from the Tokaï-Mura accident in 1997. The IRSN concluded that the safety demonstration presented by the operator was insufficient, and that additional studies were necessary to justify control of the above-mentioned risks and, if necessary to adapt the process envisaged. The Institute estimated that the operator would have to further its knowledge of the chemical nature of the sludge and the hazardous phenomena associated with the hot pre-coating process.

Finally, the IRSN examined the Definitive End of Operation (DEO) dossier for installations at the UP2-400 plant in La Hague, describing the operations planned during this phase, the organisational modifications announced and their scheduling, and the planned state of the installations at the end of the DEO phase. The Institute estimated that the operator would have to propose a sufficiently extensive change in the operating safety standard for the installations concerned and demonstrate that the provisions put in place will enable these operations to be conducted safely.

■ Long-term disposal

The IRSN examined the safety orientation dossiers presented by the CEA as part of the 3rd axis of the law of 1991, regarding the packaging and long-term disposal of radioactive waste. This investigation looked at four concepts for long-term disposal installations for HLLL or MLLL waste, on the surface or subsurface, on virtual sites.

On this occasion, the Institute provided an initial appreciation of the relevance of the design provisions envisaged by the CEA, pending the drawing up of safety option dossiers for given sites.

Safety of laboratory and dismantling of definitively shutdown nuclear installations

For laboratories, the IRSN examined in 2005 the safety of operations safety of CEA installations in Saclay (Essonne) and in Cadarache, and of the Large national heavy ion accelerator (GANIL) in Caen (Calvados), the SOCATRI uranium recovery and clean-up facility in Tricastin (Drôme), and finally, the EDF irradiated materials workshop in Chinon (Indre-et-Loire).

In addition, the main nuclear operators followed significant nuclear plant dismantling programmes which by 2025 should lead to the dismantling of about 40 basic nuclear installations. Within this framework, the IRSN examined the dossiers regarding the gas diffusion facilities (UDG) in Pierrelatte (Drôme), the EL4 reactor in Brennilis (Finistère) and the CEA's BNI in Fontenay-aux-Roses (Hauts-de-Seine).

Safety of radioactive waste transport

The IRSN examined over 100 safety dossiers regarding civilian transport of radioactive waste in 2005 (applications for approval, extension of approval, validation, certification, special arrangement or transport).

A special study to evaluate the risks of sinking in unconsolidated strata of irradiated fuel transport packages was completed in 2005. Various accidents

may occur during the transport of irradiated fuel packages to the reprocessing facility in La Hague, some of which could lead to the sinking of a package. Such a situation could affect the performances of the package as regards heat dissipation and containment of the radioactive material. The IRSN estimated the probability of such an accident and studied the thermal behaviour of the package according in particular to the depth to which it sinks. Means of intervention such as installing a cooling system were thus determined as were the times required to implement them in order to maintain containment.

Expert assessments of risks of dispersal of radioactive materials

The IRSN examined the provisions chosen by nuclear operators to ensure the confinement of radioactive or toxic materials, in order to protect workers, the public and the environment. In 2005, expert assessments on this issue in particular concerned the Georges Besse II facility project in Pierrelatte, installations being dismantled (UP2-400 plant in La Hague, EDF first generation reactors), deep disposal projects for radioactive waste, and ancillary buildings for EDF 900 MWe reactors.

Civil engineering expert assessments

Expert assessments regarding civil engineering of fuel cycle installations, laboratories and installations for waste management mainly concerned the risks associated with external hazards such as earthquakes or explosions, and monitoring of strengthening work on existing installations. Within this framework, the IRSN examined the Georges Besse II facility project in Pierrelatte, FBFC installations in Romans-sur-Isère, CEA installations Atalante Marcoule (Gard) and LECI in Saclay.

Expert assessments of criticality risks

The prevention of criticality risks are subject to specialised expert assessments. In 2005, the IRSN examined 106 dossiers with, in some cases, counter-calculations, or specific studies. The aim is to assess that the justifications presented in the dossiers of the nuclear operators and applicants are well-founded, as regards transport packages of fissile radioactive materials. It is also to check that the safety margins associated with the calculations made, in relation to the qualification level of the calculation tools used, are sufficient. Calculations to specify the criticality risks within a geological disposal of radioactive waste in very long-term evolution scenarios were carried out by the Institute. Furthermore, the IRSN analysed incidents related to the criticality risk and provided support to the DGSNR for surveillance inspections and crisis exercises for which questions of criticality could arise. Finally, the IRSN participated in the IAEA work as part of the changing international safety rules for the transport of radioactive waste.

Use of feedback of incidents

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Events regarding transport of radioactive materials

In 2005, the IRSN drew up a new database on the events which occurred during the transport of radioactive materials in France. This tool is used to monitor yearly changes in the number of incidents according to their gravity, causes and the sector of activity concerned, then to learn the technical lessons possibly to propose changes to international legislation. More than 700 events occurring since 1999 are stored in this database.

Incidents in laboratories, plants and installations being dismantled

The IRSN uses the feedback from events and incidents as part of its expert assessment of the safety of installations, especially during modifications or safety reviews. To do so, a database, called SAPIDE/LUDD has been developed since 2004. It contains all the unclassified technical data and the documentary references associated with the events and incidents affecting the laboratories, plants and installations being dismantled. Today it holds some 3,650 events and incidents, some of which occurred abroad.
In 2005, the possibility to effectively use the database was extended to all Institute's specialists. It is updated by entering the information contained in the incident reports sent by operators. They are systematically analysed to identify both the elements requiring immediate actions, and relevant feedback information for the Institute's missions.

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Key figures of the *Dossier 2005 Argile*

- 6 months of investigation, fed by research and work carried out by the Institute over the last 20 years on the safety of radioactive waste disposal;
- 82 documents in the initial dossier (more than 12,000 pages), to which are added 57 additional documents (read and analysed) transmitted by Andra at the request of the IRSN;
- 20 IRSN engineers mobilised for support studies or expert assessments, with more than 10 specialities (earth sciences, materials, transfer of radionuclides in the geosphere, radiological protection, fire, containment, etc.);
- 5 organisations called upon for studies to support the expert assessments conducted by the IRSN, including the GRS, the German counterpart of the IRSN;
- 18 technical meetings with Andra, based on 280 questions raised by the IRSN;
- 16 summary reports on the work carried out by the IRSN as part of this assessment (other summaries are in preparation);
- 1 report available on the Institute's website, presenting a 230-page opinion of the IRSN on the whole dossier;
- 5 pages of IRSN presentation presenting this opinion to the Standing advisory group of experts for installations for long-term disposal of radioactive waste, and 10 hours of discussions.

Expert assessments of internal emergency plans

In 2005, the IRSN analysed the operational nature of the PUIs of three Ionisos facilities, the Strasburg university reactor (Bas-Rhin), the Laue-Langevin Institute, the FBFC facility in Romans-sur-Isère and the CIS Bio international facility in Saclay. In addition, at the request of the Drôme, concerned with the setting up of an annual fair near the FBFC facility in Romans-sur-Isère, the Institute re-assessed the consequences of the accidents presented in this installation's PUI after the recent modifications that were made to it.

RADIOACTIVE WASTE MANAGEMENT SAFETY

The IRSN worked on the safety of the various stages in the radioactive waste management: processing, packaging, transport, storage and disposal. Different categories of waste are involved: waste of all levels of activity, mining residues and polluted soils, etc.

In 2005, given the deadline fixed by the law of 1991 on research into the management of HLLL waste, the Institute mainly examined the *Dossier 2005 Argile*, drawn up by the Andra and regarding the feasibility of geological disposal in the clay layer studied by means of the Bure (Meuse) underground laboratory.

This assessment considerably mobilised the IRSN teams in charge of this field from the summer of 2005 *(see Focus below)*.
The Institute's conclusions were presented on 12 and 13 December 2005 to the Standing advisory of competent experts. They indicate that disposal of radioactive waste in the layer studied appears technically feasible. The IRSN in particular revealed that the clay deposit presents intrinsic properties favourable to the containment of radionuclides and that Andra defined disposal concepts taking account of the main disturbances which could affect the whole containment capacity of the disposal. In view of the studies examined, this capacity should remain sufficient as regards the basic safety rule no. III.2.f to maintain satisfactory protection of man and

the environment. Respect for this rule, regarding the safety objectives of a disposal installation in a deep geological layer in particular supposes that the radiological impact at lower levels be limited to the prescribed constraint (0.25 mSv/year for the reference situation).

The IRSN nevertheless underlined that many points need to be developed in order to draw up a safety dossier associated with a possible application to create disposal: identification of any possible fracturing of the terrain at the disposal zone, validation of the performance of the containment barriers by *in situ* tests and structure "demonstrators", etc.

The Institute also examined the Dossier 2005 Granite regarding the interest of French granite formations as a medium for disposing of HLLL waste. This completes the *Dossier 2002 Granite* examined by the IRSN in 2004. The Institute confirms the conclusions it presented in its 2004 annual report, i.e. that these deep formations do not, generically, present any geological properties which hinder the installation of possible disposal.

Disposal facilities

For surface disposal installations of low- and medium-level waste, the IRSN examined specific Andra dossiers concerning the Aube disposal centre and the Manche disposal centre (general operating rules, package acceptance specifications, incident on a structure wall, extension of structure implantation zones within the scope of the BNI).

The IRSN also participated in reflections accompanying projects for radiferous and graphite waste disposal, in the subsurface or an existing cavity, developed by Andra.

Regulations on waste safety

The IRSN participates in work to draw up or revise policies concerning waste safety. Thus in 2005, the Institute continued on work concerning the required changes to the basic safety rule III.2.f, which deals with the safety of long-term disposal of radioactive waste in deep geological formations.

In addition in 2005, the Institute took part in international work by the bodies in charge of radioactive waste management, in particular:

- by taking part, invited by the IAEA, in an expert assessment mission of a surface disposal project in South Korea;
- by organising the international Tokyo conference on the safety of radioactive waste management. The IRSN presided over the programmes committee for this conference organised by the IAEA from 3 to 7 October 2005.

Impact studies on former uranium mine sites

The IRSN continued its assessment of the environmental impact of former uranium mine sites. At the request of the Prefect of the Cantal department, an expert assessment was begun into the radiological situation of the Saint-Pierre site. It aims to improve the monitoring set up when the mining activity ceased. Analysis of existing data during an initial phase, enabled the additional investigations required to study the radiological condition of the site to be specified. This work will continue in 2006 when field study and measurement campaigns are launched, following a presentation to the Saint-Pierre Local Information Commission. *(See Focus opposite)*.

Dosimeter on the Cogema site to monitor the former mine site of Saint-Pierre du Cantal.

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Assessment of the dossier regarding the mine site at Les Bois Noirs

View of the settling and treatment basins for water from the mine site in Saint-Priest-La-Prugne (Loire) before release into the environment (Besbre river).

In reply to a request from the prefect of the Loire department, the IRSN handed over an expert assessment report in 2005 on the file submitted by Cogema with a view to demolishing the SIMO facility at the Les Bois Noirs mine site in Saint-Priest-la-Prugne (Loire). Following the first dismantling phase at the start of the 1980's, the buildings had been kept and the land sold to the commune with a view to industrial conversion. This had never happened, and the buildings had been gradually deteriorating to the point where demolition was required. This demolition, and an additional clean-up of the site are paid for by Cogema. The dossier sent to the prefect aimed at depositing demolition products and "mine tailings" from the site in the open-cast mine. These "tailings", identified during a radioecological study conducted from 2000 to 2003, had been used as backfill, in particular under the sawmill platforms.
The IRSN expert assessment dealt with three main points:
- the methods used to demolish the buildings and clean and rehabilitate the facility lands;
- the methods for storage in the open-cast mine;
- the efficiency of the waste water collection and management network.

The Institute's conclusions and recommendations were presented to the Local Information and Monitoring Commission for the site in 2005. They were used in the prefectoral decrees authorising demolition and storage.

At the same time, the IRSN continued with the MIMAUSA programme (Memory and Impact of Uranium Mines: Summary and Archives), with the development of an IT database to enable the structuring and archiving of current knowledge on former French uranium mine sites.

In addition, at the request of the ministries of Ecology and Sustainable Development, of Industry and of Health, the Institute will provide technical support to the pluralistic group of experts currently being set up, whose mission will be to examine the environmental report on all former mine sites in the Haute-Vienne drawn up by Cogema, in accordance with the decree of 13 January 2004. This group should hold its first meeting in April 2006.

Writing of a guide concerning the disposal of naturally reinforced radioactive waste

At the request of the ministry of the Environment, the IRSN contributed to defining the methods of accepting waste with radioactivity which is naturally reinforced or concentrated in the disposal centres. A technical guide was written and submitted for national consultation to accompany a draft ministerial circular. Several disposal centre operators have already approached the Institute to apply the method recommended.

PROTECTION OF INSTALLATIONS AGAINST FIRE AND EXPLOSION

The expert assessment of safety dossiers regarding the risks of fire and explosion consists in assessing the validity of the provisions adopted by the operators for prevention and limitation of the consequences.

To successfully complete these assessments, the IRSN bases its work on: the results of research carried out by the Institute or other recognised bodies, the results of calculations to better appreciate phenomena, specific probabilistic safety assessments (PSA), international practices and feedback from incidents occurring in nuclear and non-nuclear facilities, in France and abroad.

Safety review of 900 MWe reactors

In 2005, the Standing advisory group of experts for nuclear reactors discussed the results of the safety review for 900 MWe reactors associated with the third 10-yearly outage programmes, as regards the risks of fire and explosion. On this occasion, the IRSN in particular analysed EDF's method to assess and control the explosion risks linked to the use and storage of flammable gases in nuclear power plants.

The results of the IRSN's fire PSA were also presented during the same meeting of the Standing advisory group. While these results confirm that the material provisions and procedures implemented by EDF as part of the fire action plan lead to a significant improvement in safety, they also show the interest of strengthening protection in some areas.

For its part, EDF will carry out a fire PSA for 1,300 MWe reactors as part of the safety review associated with their third 10-yearly outage programmes. In order to use of its own assessment tool, the IRSN also started a study into these reactors.

Future installations

The IRSN examined the safety options adopted by the operators of future nuclear installations (PSA, Georges Besse II uranium enrichment facility) concerning the risks of fire and explosion. Similarly, the Institute examined the provisions made regarding these risks in the dossier presented by Andra on the feasibility of waste disposal in the clay formation studies using the Bure underground laboratory (Meuse).

International collaboration

In the field of international collaboration, as well as continuing technical exchanges with Ukraine and Belgium, the IRSN also established contacts, in particular with technical support for the Romanian safety authority, aiming at drawing up a rule to define the provisions to be made to control the risks of fire in Romanian nuclear power plants.

RISKS ASSOCIATED WITH EXTERNAL HAZARDS

In 2005, the IRSN continued to examine the protection of nuclear sites against earthquakes and floods.

Seismic hazard

In 2005, the Institute examined the assessments of the risk of earthquake produced by the operators of several nuclear sites: Tricastin (Drôme), CEA's CESTA (Gironde), Cadarache (Bouches-du-Rhône).

[FOCUS]

Guide to assess the risks of explosion

An explosion in a nuclear installation may lead to a major accident. The IRSN assesses the corresponding risks as part of its safety expert assessments of these installations.

In 2005, a focus group of special skills developed within the IRSN in the field of explosion was set up. This group aims to capitalise on knowledge and formalise expert assessment practices concerning the risks of explosion in a guide.

These investigations are carried out as part of applications to create new installations (Georges Besse II facility, Laser Mega Joule, Agate and Cedra) or to review the documents governing the operation of existing installations (Masurca).
The Institute also gave an opinion on the relevance of the earthquake detection system for the Grenoble high flux reactor (Isère). In addition, the IRSN analysed the hypotheses retained for the EDF interregional fuel stores in Chinon (Indre-et-Loire) and Bugey (Ain), and the earthquake risk at the Brennilis site (Finistère), whose installations are currently being dismantled. Abroad, the Institute examined the hypotheses to be retained to size the sarcophage around the damaged Chernobyl reactor.
Finally, review work on technical rules regarding earthquake risk continued. After proposing an approach to define the seismic movements to be retained for each site (basic safety rule 2001.01), the Institute started a review of the rule regarding aseismic construction provisions for civil engineering works (RFS V.2.g).

Flood risk

Following the flooding of the Blayais site (Gironde) at the end of 1999, EDF re-examined the protection provisions for all its installations, and the methods for characterising the risk of flooding, in particular taking account of rainfall, tides, the level of aquifers, etc.).
In 2005, the IRSN started to investigate the methodological elements presented by EDF. A hydrogeological model was developed for this purpose, in collaboration with the *Ecole nationale supérieure des mines* (engineering school) in Paris, to assess percolation flowrates through the Donzère-Mondragon canal embankment (Tricastin site).
At the request of the DGSNR, the Institute also led a focus group comprising safety authorities, nuclear operators and flood specialist, with the aim of reviewing BSR I.2.e.

POPULATION EXPOSURE TO FALLOUT FROM NUCLEAR WEAPONS

In 2005, the IRSN dealt with the final part of the study ordered by the DPPR (Division for prevention of pollutions and risks) of the ministry of the Environment in 2003 regarding exposure of the Metropolitan population to fallout from atmospheric testing of nuclear weapons in the 1960's and 1970's.
The Institute assessed in 2005 the doses received by the population after reconstituting the evolutions of the activity of the main radionuclides present in the air, deposits and transfer into the food chain.

The reconstitutions made are based on over 45,000 results of measurements carried out by the SCPRI and the CEA between 1961 and 1980 and concern the fission products released by these explosions, measured in the air, rainwater, the main components in the food chain and the meals served in school canteens.
These data were used to assess the French population's exposure to the fallout, by inhaling the radionuclides present in the air, by irradiation and ingestion of contaminated foodstuffs. As well as the effective dose, doses to the thyroid and bone marrow were also calculated.
The wealth of the data also revealed the regional variability in the doses received, with maximum levels up to twice the average for high rainfall regions, such as the Massif Central, the Vosges, the Jura and the Alps.
The most exposed generation were people born in 1961 who were growing up when the fallout was the strongest (from 1961 to 1963). For these people, the effective dose is of the order of 1.5 mSv, with 300 µSv attributed to 1963 alone.
It should however be underlined, that the doses calculated do not take account of carbon 14, whose specific contribution is currently being assessed. Similarly, this work does not deal with special eating habits which may have led to an increase in the doses received.

ENVIRONMENTAL MONITORING

Technical support for environmental monitoring includes several actions: radiological analyses, assistance with inspections and organisation of cross-comparison exercises of measurements of radioactivity in the environment.

Monitoring of effluent releases from nuclear installations

At the request of the DGSNR, the IRSN controls liquid and gaseous radioactive effluent releases from all installations in the nuclear fuel cycle. The aim is to verify the release values reported by the operators. These measurements are also used to further the knowledge of releases from installations and to improve environmental monitoring plans accordingly.

In 2005, this activity was made concrete by a less systematic monitoring but better targeted and more in-depth from the point of view of the radionuclides measured.

A specificity in the decree of 5 March 1990 regarding the authorisation of liquid radioactive effluent releases by the Golfech (Tarn et Garonne) nuclear power plant requires special controls on activity in the Garonne immediately upstream of water intakes for supply to the town of Agen. To meet this requirement, the IRSN has set up a new automated station to measure the radioactivity of the Garonne water, due to the operating difficulties encountered with the previous station. The results are sent every month to the administrative departments concernedand to the local authorities (Drire, Ddass, town halls, CLI).

Reception of samples from BNI to monitor their discharges.

Health impact of medical-origin effluents [FOCUS]

Portable Telehydro probe immersed at the exit of a waste water collector in a Toulouse hospital.

In 2005, at the request of the DGSNR, the IRSN drew up an inventory of the practices and radionuclides used in nuclear medicine, and assessed the dosimetric impact of effluents containing patients' urine discharged into the environment.

A study was able to assess the internal and external exposure which could be attributed to iodine 131 and technetium 99 metastable which may be found in the sewer networks and treatment plants.

This study shows in particular that despite concentrations which are occasionally high in these radionuclides, personal exposure does not exceed one tenth of the effective admissible dose for the public, due to the short half-lives of these radionuclides and exposure times.

As treatment plants were not designed to deal with radioactivity, it may be released into the environment. Medium- and long-term environmental marking by these radionuclides remains to be studied.

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Increase in participation in cross-comparison exercises

Preparation of samples for interlaboratory test campaigns.

Laboratories which can feed the national network with measurements of environmental radioactivity must comply with certain qualification criteria specified in the public health code and in a decree of 27 June 2005.
In this regard, at the request of the DGSNR, the IRSN organises exercises of cross-comparison of environmental radioactivity measurements. These exercises deal with the analysis of low level radionuclides, of natural or artificial origin, in various samples (water, soils, biological matrices, filters, etc.). In 2005, 123 participants from 45 different laboratories participated in these exercises, representing a 20% increase on 2004. Indeed, the same laboratory can participate in several exercises during the same year.
In order to facilitate the traceability of these test results, the IRSN developed special software in 2005. Its aim is to manage the database of participating laboratories (enrolment, communication and recording of results) and to carry out the various statistical processes on the measurement results.
In addition, the Institute's means of preparation and measurement enabled cross-comparison to be proposed for the first time in 2005, on measurements of aerosols deposited in filters. The use of the ICARE bank located in Saclay (Essonne) enabled uniform deposits of strontium and caesium aerosols to be created with properties representative of the deposits commonly encountered by laboratories.
The Institute continued its approach with a view to obtain Cofrac accreditation as an "organiser of interlaboratory comparisons".

Support for inspections

The IRSN assisted inspectors of basic nuclear installations during certain site visits – Chooz (Ardennes) in June, Nogent-sur-Seine (Aube) in October, Pierrelatte (Drôme) in October – and carried out individualised sampling of releases at the request of the inspectors.

National network of environmental radioactivity measurements

An order issued on 17 October 2003 placed the technical management of the National network for environmental radioactivity measurements under IRSN responsibility. This network will compile the results of measurements collected over the years by public establishments, government departments, nuclear operators, local authorities and associations. In particular, the IRSN is to provide the secretarial services for the steering committee prescribed by the order and take charge of the centralisation, processing and archiving of analysis results.
It is also required to make data available to the general public on a website. In 2005, the principal strategic and technical orientations were defined and the audits conducted by the Institute on the steering committee members were used to design the specifications of the future information system.

TECHNICAL SUPPORT IN THE FIELD OF RADON

At the request of the DGSNR in 2005, the IRSN drew up a list of the various cartographic studies predicting zones affected by radon conducted in around 40 departments on behalf of the Ddass or Drass.

These local studies were carried out by 10 or so different bodies (BRGM, university laboratories, private firms, decentralised administrations) and according to different methods. The work performed by the IRSN enabled it to offer general elements to be retained to classify geographic zones according to their potential to be radon sources. The accuracy of the mapping may, in the best cases, reach several hundreds of hectares.

RADIOLOGICAL PROTECTION RESPONSE AND ASSISTANCE

In 2005, the public authorities, at national or local level, called on the IRSN 12 times for various work, following the discovery of sources of ionising radiation in inappropriate places.

For example, final radiological testing after cleaning in a residence contaminated by radium in the *rue du Paradis* in Paris. This type of intervention consists of characterising the quantity and quality of the radionuclides present and the extent of the contaminated zones, then making the premises safe by suitably packing and storing of the contaminated materials or sources with a view to their final disposal by suitable means.
Other types of intervention were carried out by the Institute in 2005: radiological protection assistance for interventions on contaminated sites, such as in Bandol (Var) to clear land contaminated by radium, technical support during inspections conducted by the public authorities (SATURNE accelerator in Saclay) or work on sites contaminated by radium (Gif-sur-Yvette).

Type of object used by the department of intervention and assistance in radiological protection in its mission to collect sources.

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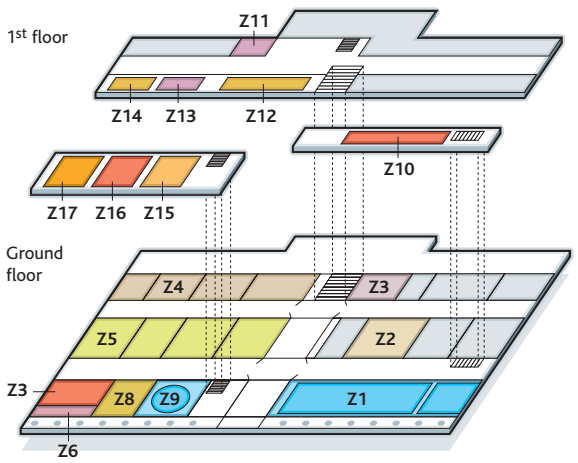
Radon measurement in spas



Determination of homogenous occupied zones (Z) from the Bagnères-de-Luchon establishment for radon.

Radon measurements must be carried out in spas to meet changes in French legislation regarding the management of the risk associated with radon in premises open to the public. Given the special nature of these establishments (existence of several sources of radon, especially damp atmosphere, seasonal activity), the provisions of the AFNOR standard NF M60-771 regarding detection cannot be complied with.

A special method was drawn up in 2005 by the IRSN at the request of the DGSNR. The changes made in relation to the standard mainly concern the type of measurement devices to be used and the determination of homogenous zones in buildings (zones with the same properties in terms of penetration and distribution of the radon).

For treatment premises, the determination of these zones requires the estimation of the radon dose by the therapeutic agent (water, gas, steam, mud), the influence of the "ground" source (basement, ground floor, etc.) and the ventilation conditions, be they continuous, partial or inexistant.
This method was tested and validated in 2005 at the Bagnères-de-Luchon (Haute-Garonne) spa before being implemented nationwide.

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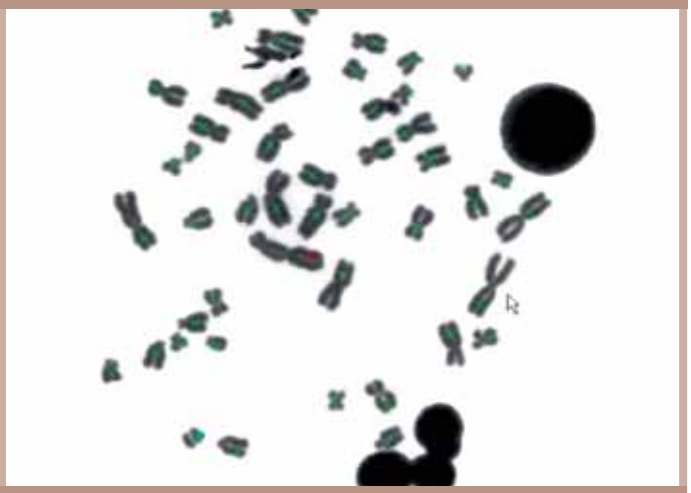
Reconstitution of a dose after a radiological protection incident



Counting of chromosomal aberrations in biological dosimetry.

During 2005, the IRSN made a dose reconstitution following the accidental exposure of a worker during the characterisation of a new X-ray generator. The victim, who was not wearing his individual dosimeter, showed redness on the right clavicle a few hours after the exposure. Clinical, biological and physical estimations of the dose were immediately carried out in parallel. The clinical examination indicated exposure of the skin of several grays. Biological dosimetry, using dicentric chromosomal aberrations within the lymphocytes, led to an estimated dose of 100 mGy. The associated confidence interval [0-250] does not enable a zero dose to be excluded. Finally, the physical dosimetry specified that, given the very low energy of the radiation, the dose was deposited very locally and superficially. Thus, although the dose received on the skin is high, it is not inconsistent to measure a low dose by biological dosimetry.
All these elements were used by the occupational physician to decide whether or not to keep the worker in controlled zone.
This incident shows the advantage of collaboration within the Institute between the teams working on the physical and biological characterisation of the dose.

RADIOLOGICAL PROTECTION OF WORKERS

The IRSN technical support for the Department for labour relations as regards radiological protection of workers in particular concerns participating in drawing up regulatory texts and knowledge of the exposure.

In 2005, the IRSN gave its opinion on various draft legislation concerning training of competent persons in radiological protection, worker exposure to radon, zoning of installations, radiological protection tests and declaration of incidents occurring in the installations (excluding BNI).
In addition, the Institute approved the dosimetric monitoring techniques implemented by three organisations for external dosimetry and three organisations for internal dosimetry. These opinions are provided as part of the investigation for certification of these organisations by the ministry for Labour.

The results of exposure of workers in 2004 were drawn up based on data sent by IRSN passive dosimetry laboratories and by approved organisations. Roughly 255,000 workers are concerned. The medical and veterinary sectors employ 56% of these workers. The total collective dose received amounts to 64 man.sievert. This total dose has been falling steadily for the last 10 years. In 2004, 51 people received a dose greater than the statutory limit (20 mSv/year). The number of these excessive values has remained relatively stable since 2000.

Scanner interpretation room at the Cochin hospital.

However, three sectors of activity repeatedly present doses greater than 20 mSv: medical radiology, the non-nuclear industry (mainly non-destructive testing using gammagraphy) and the subcontrating companies for the main nuclear operators.
Depending on the specificity of the work stations and the radionuclides handled, a certain number of workers are also subjected to additional dosimetries: "neutron" dosimetry and dosimetry of the extremities.

The global result that can be concluded is that the fall in collective doses observed since 1990 is continuing, while the number of workers in the same period has risen overall.

RADIOLOGICAL PROTECTION IN THE MEDICAL FIELD

Radiological protection of exposed personnel for medical purposes is based on two principles: justification of medical acts and optimisation of exposure.

In 2005, as part of the action plan to monitor the exposure of patients to ionising radiation of medical origin (PASEPRI) drawn up by the DGSNR, IRSN actions were carried out in three fields: completion of a report into medical exposure of the French population, jointly written with the InVS, the collection of dosimetric information to draw up diagnostic reference levels and dosimetric studies regarding premature babies and dental radiology.

Medical exposure of the French population to ionising radiation

In 2005, collaboration between InVS and the IRSN enabled a report to be drawn up on the medical exposure of the French population to ionising radiation. Knowledge of the distribution of radiological examinations and their associated doses is necessary to estimate the contribution of medical exposure to the doses received by the population. It also enables changes to be understood in order to specify the impact of new techniques, new protocols, or even new legislatory provisions.
Under these conditions, the IRSN and InVS have

Report on medical exposure of the French population.

decided to coordinate their efforts to implement a sustainable information system on medical exposure of the French population to ionising radiation. A report of the data available (CNAMTS and Annual health establishment statistics) was drawn up. This report shows that, according to the hypotheses taken, 61 to 74 million acts (including dental radiology) were carried out in France in 2002. Conventional x-rays represent 90% of examinations, scans 7% to 8% of examinations and interventional radiology and nuclear medicine together about 2%.
The trends noted in this study compared to previous studies (1982, 1988, 1994) reveal:

- a marked reduction in some traditional x-ray examinations without preparation such as x-rays of the thorax and skull, examinations which have fallen by about half in the last 15 years;
- a significant fall in examinations with opacification which are 10 times less numerous than in 1982;
- stability in x-rays of the abdomen and the vertebral column;
- a significant development in scanning which has tripled in 15 years.

The average individual effective dose is between 0.66 and 0.84 mSv per year. Traditional x-ray examinations contribute to 35% of the total dose given to the population, those of scans to about 40% and nuclear medicine and interventional radiology to 20 to 25%.

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Study of the doses received by premature babies

Traditional x-ray.

In 2005, the IRSN conducted a study into the doses received by premature babies, one of the most sensitive populations to radiation. For clinical monitoring, these newborns are subject to more and more x-rays. The IRSN study looked at 184 examinations carried out on the reanimation ward at the Antoine-Béclère hospital on 63 premature babies weighing from 500 grams to more than 2,500 grams. The dose to the skin, which depends mainly on weight, varies from 20 µGy to 37 µGy per x-ray and the average number of x-rays per premature baby can reach 20 during its stay. The study showed that a 30% saving in the dose can be envisaged by using digital detectors. This saving will be validated at a later date when this technique has been implemented and adapted to the characteristics of x-ray examinations in premature babies.

Updating of diagnostic reference levels

Since March 2004, legislation obliges the managers of radiology and nuclear medicine installations to provide the IRSN every year with dosimetric information regarding the most common examinations. These provisions concern almost 4,000 x-ray installations, 700 scanners and 200 nuclear medicine departments.

A professional information phase concerning this new legal obligation was initiated by the IRSN. At the end of 2005, data from 29 radiology departments (including scanning) and from 78 nuclear medicine departments was collected. These data show the variable practices in place according to the establishments: for example, in nuclear medicine, the activity administered for a given type of examination may vary by a factor of almost four.

Awareness and information campaigns for the personnel concerned will be continued in order to increase the data collected.

Dosimetric studies in dental radiology

In order to contribute to guidelines for prescriptions and dental radiology examination procedures, a first phase had to be initiated to draw up diagnostic reference levels in this field.

To do so, the IRSN conducted dosimetric assessments for 16 of the most common procedures and for 11 radiological devices, including the scanner, in 2005. The doses measured on the skin range from less than 1 mGy for a traditional x-ray to 25 mGy for tomography.

With the advance in technology, digital detectors are replacing photographic film. The fall in dose often associated with digital detectors however, has not been observed for all procedures. This can only be realised after a concrete approach to optimise procedures.

MULTILATERAL SCIENTIFIC CO-OPERATION: STRENGTHENING THE IRSN'S CONTRIBUTION TO IAEA AND OECD/NEA WORK

At the end of May 2005, an IRSN delegation, led by the general manager, met the heads of nuclear safety and security programmes and of IAEA technical co-operation in Vienna.

The role of these meetings was to:
- enable the Agency managers to better know the missions and activities of the IRSN;
- know better the activities the Agency wants to develop, and the possible collaborations between the two organisations;
- reinforce the IRSN's contribution to IAEA work in drawing up standards and international consensus.

New actions were undertaken to follow on from these meetings: preparation of the IRSN interventions during international conferences and its contribution to organising an IAEA conference in France on safety expert assessment in April 2007. Every year, participation in IAEA focus groups and training activities represents more than one person/year and security inspection missions correspond to two people. In addition, six IRSN experts were seconded to the IAEA on 31 December 2005. The Institute also strengthened its presence within NEA bodies, with the election of Mr Philippe Jamet to the position of vice-president of the CSNI committee for research into nuclear safety. In 2005, the Institute continued its contribution to several focus groups in this organisation.

Strengthening of co-operation with China

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Co-operation between the IRSN and Chinese radiological protection health organisations continued in 2005 at a steady pace, with monitoring by means of meetings of the boards. The Institute welcomed seven Chinese trainees for stays of six months to one year. These training courses dealt with radiological protection for man and questions of nuclear safety (probabilistic safety assessments, safety examinations, use of the thermohydraulic accident code CATHARE and the ASTEC code for severe accidents). The training courses concerned engineers from the Chinese safety authority NNSA, its technical support NSC and the China National Nuclear Corporation (CNNC) with whom the IRSN signed co-operation agreements.
Similarly, two visits (one to France and the other to China) took place in 2005, as part of the safety review of the experimental Chinese fast neutron reactor CEFR.
In addition, at the end of May 2005, the IRSN hosted a large delegation from the CNNC, which enabled new areas of co-operation in the field of human radiological protection to be identified. Finally, IRSN played a significant role in the organisation of two seminars in China, one dealing with the safety of the EPR reactor project *(see Focus Seminar in China on the EPR reactor project*)*, the other devoted to research and development into severe accidents.

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EUROSAFE 2005

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The EUROSAFE project aims to contribute to converging technical nuclear safety practices in a widened European context. This approach is backed up by three supports: the EUROSAFE Forum, *the EUROSAFE Tribune* and the EUROSAFE website. Until now organised by the IRSN and the GRS alternately in France and Germany, the 2005 Forum was organised with the AVN in Brussels for the first time, and was devoted to improvements in safety. One and a half days of scientific and technical presentations brought together almost 420 experts from safety organisations, research institutes, safety authorities, industries, public authorities and NGOs from the European Union, Switzerland and Eastern European countries. All information on the forum, the texts of the presentations and issues of the *EUROSAFE Tribune* are available from **www.eurosafe-forum.org**.
The next days, jointly organised by AVN, the IRSN and the GRS, will take place in Paris on 13 and 14 November 2006.

Operational support in the event of a crisis or radiological emergency

The IRSN provides support to the public authorities on regulatory, methodological and operational aspects of the national organisation to be implemented in order to relevant to a crisis or radiological emergency. The Institute ensures that this assessment is relevant by permanently evolving its assessment tools and means of intervention and by forging close relations with the various actors and parties concerned.

Treatments of individuals potentially irradiated in the Institute's LMR laboratory truck.

Regulatory aspects of emergency situation management

As part of its support to the authorities in drawing up legislation, in 2005 the IRSN contributed to developing an interministerial directive on the conducting and processing of measurements of environmental radioactivity. The Institute also participated in developing a circular defining the principles of intervention for an event which could lead to a radiological emergency excluding situations covered by a contingency or intervention plan. These two texts, dated respectively 29 November 2005 and 23 December 2005, in particular specify the operational missions of the IRSN to the local public authorities who may be in charge of managing radiological emergencies.

The interministerial directive of 30 November 2005 regarding the application of the international convention on assistance in the event of a nuclear accident also specified the means for implementing this assistance, to which the Institute may contribute, in particular in terms of aid in diagnostics and treatment of contaminated or irradiated victims.

CRISIS MANAGEMENT

The IRSN provides operational support to the public authorities in a radiological emergency. Depending on the circumstances, the Institute may engage all or part of its expert assessments or intervention means.

To do so, the Institute avails of:

- a Technical Crisis Centre equipped with a wide range of assessment tools;
- mobile intervention means enabling testing of people and measurement of environmental radioactivity;
- methods to assess individual exposure (biological dosimetry, dosimetric reconstitutions, etc.)

Continuous improvement of these means and their engagement during exercises, or real situations, regularly enable their effectiveness to be appreciated.

Organisation, methods and materials

In terms of organisation, 2005 saw a strengthening of the IRSN mobile cell sent to the location of a radiological emergency, with in particular, the creation of the position of head of this cell and improvement of its links with the Institute's Technical Crisis Centre (CTC). In addition, all the job descriptions for crisis team members at the CTC were drawn up or revised.

In order to ensure continuous development and improvement of the expert assessment methods used at the CTC, an initial reflection was conducted in 2005 on changing the diagnostic/prognostic method used to manage an accident which might affect an EDF reactor in operation. At the same time, adaptation of this method to the reactors onboard new generation submarines (SNG) was examined in concertation with French Navy staff.

Not only for methods, major evolutions were made to some expert assessment aid tools, in particular the SESAME system which enables releases in the event of an accident affecting an EDF reactor to be assessed and the atmospheric dispersion codes and calculation of the radiological consequences. The development of a new tool for post-processing of data and cartographic representation was also commenced. The operational documentation (summary description sheets of installations, model accident sheets, data on the instrumentation of installation chimneys) regarding laboratories and facilities, Navy installations and transports has been completed.

The manager of the IRSN mobile cell in discussion with his team members defining the appropriate action plan.

Real actions of the IRSN's CTC for real situations

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The Institute's Crisis Centre was activated on 30 September 2005 following a water leak at the Nogent-sur-Seine power plant.

In 2005, two incidents concerning EDF plants led to the implementation of the national crisis organisations and thus to real actions by the Institute's CTC.

The first took place on 30 September at the Nogent-sur-Seine plant (Aube) after a water leak from the secondary circuit via the drainage valves left abnormally open which led to the appearance of faults in the protection system equipment on reactor no. 1 *(see Focus Incident in Nogent-sur-Seine*)*. The second occurred on Thursday 27 October when the untimely closure of a valve caused an increase in the pressure of the primary water circuit in reactor no. 3 at the Blayais power plant (Gironde).

These two incidents confirmed the responsiveness of the IRSN crisis teams. In both cases, the assessment mainly consisted of diagnosing the condition of the installation and examining the safety level resulting from operations to make the installation safe. Using feedback from these incidents, reflection is being conducted on the role of the IRSN in "infra-PUI" situations (situations which could trigger the internal emergency plan [PUI]).

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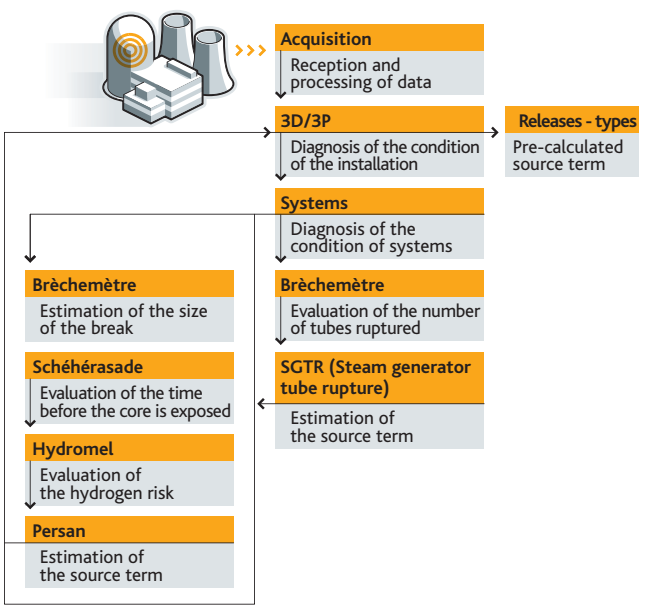
Use of pectin to decorporate caesium 137

In April 2005, the French ambassador to Belarus called on the IRSN with a view to making a pluralistic assessment of the effectiveness of pectin and the opportunity for its use on land contaminated following the Chernobyl accident. The IRSN initially conducted a bibliographical analysis of the advanced scientific and technical arguments to clearly identify the controversial points and any gaps in knowledge concerning the use of pectin as a food additive to capture radionuclides (especially caesium 137) in order to help their elimination. The summary of the 54 documents examined reveals that the work undertaken to assess the effectiveness of pectin does not enable a definitive opinion to be given on whether it is helpful to administer pectin in order to reduce the concentration of caesium 137 in the human body. Following its analysis, the IRSN specified that it would be useful to complete knowledge regarding the advantages of the use of pectin. Only experimental studies on animals supplemented by clinical studies would provide the information essential for assessing the advantages of pectin for children living on land contaminated by the Chernobyl accident.



The SESAME system is comprised of a set of modules used to assess radioactive discharges in the event of an accident on a PWR.

Evaluation of radioactive releases in the event of an accident

Version 3 of the SESAME system is currently the IT tool used by the CTC to evaluate radioactive releases in the event of an accident affecting an EDF nuclear reactor.

In 2005, EDF modified the data transfer system from reactors to the crisis centres. These modifications led the IRSN to develop new software during the same year to collect the parameters from a supposedly damaged reactor. This software, called ACQUISITION 4, is the first element in the development of version 4 of the SESAME system carried out in full by the Institute as part of continuous improvement of its crisis tools. Thus, SESAME 4 will take account of changes in hardare and software and advances in R&D in the field of severe accidents, to develop the physical models used in the various modules.

The scope of application of the SESAME system will also be extended to new accident situations (shutdown situations).

These changes to the SESAME system will take account of feedback from the use of the previous version and of the needs expressed by the experts who may be called to the CTC.

Special attention will be paid to maintaining compatibility between the modules of the old tool and those of the new, in order to enable simultaneous use during the gradual implementation of the nine programmes which will make up the SESAME 4 system by the end of 2007.

Evaluation of environmental consequences in the event of an accident

Feedback from the use of operational tools to evaluate the environmental consequences of an accident situation and the appearance of new needs, in particular as regards centralising and interpreting measurements from the environment, will require a new operational platform to be developed at the CTC.

This will include:

- a new tool to calculate the consequences, whose the main specifications were defined in 2005, used to make all the atmospheric dispersion calculations and the radiological consequences in the event of an accident and will be based on dispersion models on the local and national scales;

- a tool to centralise the results of environmental measurements, a new version of which was developed in 2005;
- a new post-processing tool for all results calculated or measured.

This operational platform will be installed at the CTC from 2006.

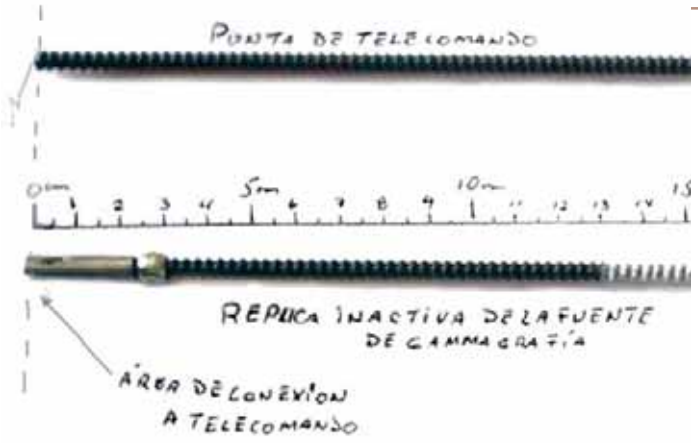
Exercises and feedback

15 national exercises were organised in 2005 by the public authorities in order to test the national crisis organisation and systematically led to the activation of the Institute's CTC and dispatching of its mobile cell to the prefecture's operational command post (PCO). These exercises on various installations such as power reactors, transport, military installations, etc., with a wide range of situations, showed the need to progress in harmonising working methods (expert assessment method, permanent links, specific preformatted messages, etc.) between the IRSN and the operators, in order to enhance exchanges during a crisis situation. These exercises also confirmed the need to continue with efforts undertaken to improve coordination and interpretation of environmental radioactivity measurements, in order to fully fulfill the missions entrusted to the IRSN by the interministerial directive of 29 Novermber 2005 regarding taking and processing of environmental radioactivity measurements.

IRSN Technical Crisis Centre: audioconference with EDF during an exercise.

Gammagraphy source accident in Chile

[FOCUS]



Gammagraphy source accidentally handled by a Chilean worker.

On 15 December 2005, three workers were accidentally irradiated by a source of iridium 192 (3 TBq) used in industrial gammagraphy in a cellulose factory under construction in Chile. The Chilean government called on international aid, and a team from the IAEA including a physician from the IRSN conducted an expert assessment and assistance mission with the medical teams in charge of the victims. As one of the victims had been severely irradiated, the experts recommended transfer to an international centre specialised in the treatment of accidental irradiation victims. The worker was thus hospitalised on 29 December in the burns unit of the Percy army teaching hospital in Clamart (Hauts-de-Seine).

The IRSN technical support was decisive in guiding the surgical procedure to remove an extended zone of tissue which had received doses in excess of 20 Gy. The IRSN was able to provide quick and accurate dose mapping on the surface and indepth of the irradiated zone. This mapping is based on the distribution of doses assessed using digital modelling and on the measurement of the dose at a point of the body, i.e. the exposed iliac crest. For the first time, it combines digital modelling with electronic paramagnetic resonance (EPR) measurements conducted on a bone biopsy. This association enabled a new treatment strategy to be drawn up.

[FOCUS]

Post-accident crisis exercise

Testing of decontamination techniques on buildings by SDIS teams in the Cher department.

National exercise in Belleville-sur-Loire

The national crisis exercise scenario on 22 March 2005 which involved the EDF site at Belleville-sur-Loire (Cher) enabled certain specific issues arising in the first hours of a post-accident phase to be dealt with: implementation of sales restriction orders, lifting of population sheltering, deployment of means to characterise radioactivity in the environment, etc.

Following this exercise, a focus group piloted by the IRSN and comprised of representatives from decentralised government departments (DDE, SDIS, Ddass), representatives from local associations and town halls, discussed the rehabilitation operations to be undertaken on buildings contaminated during the first days. This reflection led the fire and safety departments of the Cher and the IRSN to organise in November 2005 a simulation of the implementation of cleaning counter-measures of a building in order to specify the order of magnitude of some parameters such as the quantities of water required for cleaning, the times to carry out actions of the material and human means required for this purpose. This exercise and the actions which followed it confirmed the advantage:

- for the local authorities of availing of the Institute's support at the prefecture's fixed command post, in particular to supplying the technical explanations required to understand the situation and appreciate the challenges associated with the various actions to be undertaken from the very start of the post-accident phase;
- for the IRSN, of availing of operational data and involving the various stakeholders concerned in defining rehabilitation actions and the way of implementing them.

Finally, the principle of regular technical meetings between the IRSN and the DGSNR, and between the Institute and the DSND was reviewed in 2005, in order to examine bilaterally and in detail the lessons to be learnt from the crisis exercises and the areas for improvement in terms of advice to the local authorities.

SUPPORT IN MANAGING POST-ACCIDENT SITUATIONS

The IRSN's operational organisation to deal with post-accident situations was developed in 2005. New IT tools were developed and, as part of consultation with local actors, the expert assessment approach was improved, in order to better anticipate the actions to be taken in the post-accident phase immediately from the emergency phase.

Changes to DATARAD data collection tool

In 2005, the Institute developed version 2 of DATARAD, a tool to collect environmental radioactivity measurements during an accident situation. This tool is used to centralise and interpret, at a national level, all the results of measurements and sample analyses made in the environment during the crisis, within the framework defined in 2005 by the public authorities.

Changes to the tool concerned:

- improvement of the integration of DATARAD into the operational chain of CTC IT tools;
- repatriation to the CTC of the values measured by the IRSN monitoring networks and operators, centralised at the IRSN site in Le Vésinet (Yvelines);
- ergonomy of the user interface given feedback from the use of version 1 of DATARAD;
- implementation of recent IT technology.

Rehabilitation strategies

Rehabilitation of a contaminated environment following a nuclear accident aims to reduce the levels of radioactivity in the environment and its impact in terms of the doses to populations. Numerous actions can be undertaken to rehabilitate contaminated land. However, their application

requires the use of often heavy human and technical means and must take account of the times required to carry them out, the exposure of workers and the waste produced.
In this regard in 2005, the IRSN undertook to develop a tool to compare rahabilitation actions (ICAR project) in post-accident phase, taking account of the many aspects of such a situation.

Management of a post-accident phase

In April 2005, the public authorities implemented a steering committee in charge of drawing up doctrine regarding the management of the post-accident phase of a nuclear accident.
In an initial phase, six interministerial focus groups were created to lead reflection on the following aspects:

- evaluation of the radiological and dosimetric consequences;
- health monitoring of victims and populations;
- life in contaminated rural territories, agriculture, water;
- waste management, contaminated products and soils;
- compensation;
- lifting of emergency population protection measures and rehabilitation of buildings.

The IRSN led the group responsible for evaluating the radiological and dosimetric consequences and will be participating in other focus groups.

In addition, the IRSN participated in the indoor exercise INEX 3 organised by the OECD/NEA on 9 December 2005. This dealt with the consequences and the measures to be taken following a radioactive release: decontamination, rehabilitation, waste management, impact on trade, compensation of a contaminated agricultural sector (cereals), etc. This exercise brought together local and national actors.
The IRSN participated in preparing and leading the scenario and, as an actor, in the different focus groups set up.
Although voluntarily limited to the agricultural sector, the lessons learnt from this exercise are many and should contribute to feeding the reflections of the post-accident steering committee.
This exercise, conducted by several countries, will be debriefed at the start of 2006.

IRSN mobile intervention means [FOCUS]

During 2005, the IRSN developed a replacement and modernisation plan for its mobile intervention means in radiological emergency situations. This plan has the following goals:

- greater efficiency, by abandoning versatime means in favour of means dedicated to measuring or analysing environmental samples and radiological testing of individuals;
- greater flexibility and rapidity of deployment by replacing heavy or semi-heavy-duty means with light vehicles;
- total communication autonomy, even when standard telephone networks are saturated.

Four emergency intervention vehicles were acquired in 2005. During the coming years, they will gradually be associated with three laboratory vehicles, six vehicles for radiological testing of individuals and a vehicle to coordinate all the means deployed by the Institute in the field.

Operational support in case of crisis

The IRSN provides the prefect with the various elements of its mobile cell, according to the nature of the crisis situation:

- a "measurement coordination" team, in charge of drawing up measurement and sampling plans, collecting and controlling all the results of measurements and analyses;
- a "measurement means" team, in charge of conducting measurements and samples in the environment and radiological monitoring of people.
- a "package inspection" team, in charge of evaluating the condition of the damaged packages in the event of a transport accident.

In 2005, the first two elements of the Institute's mobile cell were mobilised for each exercise. During the "transport" exercise in the Val-d'Oise on 22 September, the "package inspection" team was also mobilised.

Key figures 2005

Key figures 2004

1,610,000 personal dosimeters supplied and used

1,714,000

856 analyses of drinking water carried out

1,019

145 analyses of foodstuffs carried out

150

127 radiological protection operations

150

42 third-party surveys

43

CONTRACTUAL SERVICES IN EXPERTISE, RESEARCH AND MEASUREMENTS

The IRSN carries out expert assessment and measurementservices on behalf on institutions and industrialists who request them. The Institute provides its skills and know-how, while at the same time ensuring that these services remain compatible with its mission to provide technical support and assistance to the public authorities. Some of these services are related to statutory requirements. Selling services is also a way of optimising the use of technical tools developed for research programmes. The services provided, excluding co-financing of research, correspond to about 5% of the Institute's current budget.

134 **Services related to statutory requirements**

138 **Services not related to statutory requirements**

Services related to statutory requirements

RADIOLOGICAL TESTING OF WATER INTENDED FOR HUMAN CONSUMPTION

Within the framework of legislation to protect consumers, the IRSN provides radiological analysis services of water intended for human consumption.

The IRSN analysed 856 water samples in 2005. The radiological quality of water intended for human consumption is assessed according to a protocol, defined in the order of 12 May 2004, which sets out the inspection methods. According to the values obtained for certain parameters (activity a total, b total, tritium), additional analyses may be required, as was the case in 13% of the water inspected in 2005.

150,000 workers
monitored by external dosimetry
(150,000 in 2004)

20,234 radiotoxicological analyses
(21,089 in 2004)

208 anthropogammametric analyses
(125 in 2004)

8 dose assessments
by biological dosimetry
(15 in 2004)

Laboratory in which radiological water inspection is carried out (Le Vésinet).

In 2005, the IRSN published a descriptive file of services it is able to provide concerning radon.

However, less than 1% of the water led to an effective dose, due to the incorporation of radionuclides present in the water during one year of consumption, greater than the threshold value of 0.1 mSv fixed by a Euratom directive, based on WHO recommendations.

RADON DETECTION

Within the framework of risk management related to radon in buildings, the IRSN provides detection services and conducts further investigations as defined in the regulations. In 2005, radon measurements were conducted in several establishments open to the public (schools, town halls, creches, holiday centres, retirement homes, hospitals, etc.).

The IRSN's department concerned received ISO 9001 certification from Afaq for studies and expert assessments conducted in radon control. In 2005, the revenues from these services increased by 120%.

RADIOLOGICAL PROTECTION OF WORKERS

Within the framework of the decree no. 2003-296 of 31 March 2003, regarding the protection of workers against ionising radiation, the IRSN conducts measurements on the exposure of workers. It also carries out expert assessments such as workstation studies, and consultancy, for example to support occupational physicians and people involved in radiological protection.

Monitoring of external exposure of exposed workers

The IRSN avails of one of the main laboratories in France to determine the external exposure of workers exposed to ionising radiation.
In 2005, roughly 150,000 workers belonging to 17,000 establishments wore dosimeters supplied and developed by the Institute. This laboratory processed 1,500,000 photographic dosimeters, 60,000 thermoluminescent dosimeters for exposure to gamma and beta radiation, and 50,000 trace detection dosimeters (PN3) for exposure to neutrons.

Monitoring of internal contamination of exposed workers

Assessing the exposure of workers at risk of internal contamination is conducted by determining the incorporated activity in the body. Two types of analysis are used: measurement of incorporated activity via whole-body radiometry and measurement of excretion activity via radiotoxicological analyses of urine and stools. In the course of 2005, the IRSN conducted 208 whole-body radiometry examinations. Radiotoxicological monitoring was conducted for 3,600 workers. For this purpose, of the various biological samples processed, 20,234 analyses were carried out. 64 different radionuclides were thus measured.

Changes in external exposure monitoring

[FOCUS]

Passive dosimeter.

In 2005, three major projects regarding external exposure monitoring were started by the IRSN.
The main aim is to replace the photographic dosimeter with a thermoluminescent dosimeter (TLD) or a radiophotoluminescent (RPL) glass dosimeter.
This action is partly motivated by the uncertain future of production of the silver film used in current dosimeters.

To do so, a call for tender was launched in November 2005, the aim being to start implementation of the new technique towards the middle of 2007.
At the same time, a unique laboratory management IT system more geared towards various customers (DOSIP) is in progress.
Finally, it is planned to obtain laboratory certification according to the ISO 17 025 standard in 2006 and preparations for this certification were initiated in 2005.

CONFORMITY OF MATERIALS AND EQUIPMENT

Within the IRSN, two technical centres can conduct actions regarding the conformity of materials and equipment with regard to technical standards or specifications. In their fields of expertise, they take part in drawing up statutory and normative texts for France and for other countries.

[FOCUS]

Cross-comparison of operational dosimeters

Active dosimeters.

The IAEA organised an international cross-comparison exercise of individual operational dosimeters, targeted on measuring the dose equivalent in a β and γ radiation field. During 2005, the IRSN, the Mol research centre (SCK-CEN, Belgium) and the CEA also defined and produced the various irradiation conditions used for this cross-comparison in their installations. During the cross-comparison, the performance of the operational dosimeters were assessed in relation to the requirements of the CEI 61526 standard for typical beams and for realistic radiation fields simulating workstations. In total, 13 different models of operational dosimeters from nine suppliers were tested. The IRSN thus irradiated these dosimeters in its facilities producing reference photons. The IAEA report presenting the results of the cross-comparison will be published in the course of 2006.

The expertise of the IRSN's Technical Centre for Radiological Protection Instrumentation Approval (CTHIR) involve measurements of individual dosimetry and atmospheric dosimetry, measurements of air contamination and detection of criticality accidents. Since the end of 2002, the conformity of materials associated with these measurements is examined within the framework of the ISO 9001 quality system.
In December 2005, the AFAQ granted renewal of certification for a period of three years. The CTHIR uses the IRMA irradiator, an installation in which irradiations designed to assess the resistance of materials to gamma radiation are carried out. The campaigns conducted in 2005 lasted 34 weeks in total.

STATUTORY INSPECTIONS IN RADIOLOGICAL PROTECTION

On behalf of third parties or users of sealed or non-sealed sources, operators of equipment or installations using ionising radiation sources, the IRSN conducts inspections relating to the statutory requirements to which the latter are subject. These services deal with the protection of individuals against the dangers of ionising radiation, as part of the public health code or the labour code.
Numbering 15 in 2005, these inspections consisted of checking that sealed sources were not contaminating, conducting a radiological inspection for the absence of contamination of certain premises

Statutory inspection in radiological protection at the CRECEP (94).

for the purposes of radiological declassification or ensuring satisfactory radiological safety of equipment operation.
The IRSN also carries out *in situ* inspections of the efficiency of very-high efficiency (VHE) filters and iodine traps in the ventilation circuits of basic nuclear installations: 16 such inspections were carried out in 2005.

NON NUCLEAR SERVICES

The IRSN puts the skills it has acquired in the nuclear field to use in services provided to industrialists outside this domain.

Odor expertise

For more than 30 years, the IRSN has provided expertise in the field of odors, thus enabling industrialists to take the appropriate corrective measures if necessary.
With the improvement in the quality of living, the population is less and less tolerant of olfactory pollution, the second reason behind complaints in France. The answer to this evolution is based on statutory and normative elements. Legislation, centered originally on the issuing environment and more specifically on the channeled sources, did not meet the concerns of residents. Despite compliance with provisions regarding the emission of polluting substances, these residents continued to expressed a disturbance. Based on this situation, the new regulatory texts require that all sources are taken into consideration and fix limit values in the receiving environment. Within this context, the IRSN was consulted in 2005 by the ministry for the Environment concerning the future order regarding composting sites, in the same way as for the drawing up of the order of 12 February 2003 regarding rendering plants, currently in application.

In 2005, the IRSN conducted 15 expert assessments in various industrial installations. In addition, the Institute continued to pilot the Afnor X43F Commission, research work in collaboration with Ineris and teaching activities in initial training (DUT, engineering school [Esigec]). It also started a study programme into olfactory disturbance.

The team from the BAIN (Bureau of Analysis of non-nuclear installation safety).

Non-nuclear third-party surveys

The IRSN is recognised as a third-party expert by the ministry for the Environment, to carry out critical analyses of studies of the dangers of industrial installations classified for the protection of the environment. In order to carry out these analyses, the Institute relies in particular on its skills acquired in the field of nuclear safety.
Among the 40 or so critical analyses carried out by the IRSN in 2005, can be mentioned those regarding the Total refinery at Donges (Loire-Atlantique), Arkema chemical plants in Saint-Auban (Alpes-de-Haute-Provence), Pierre-Bénite (Rhône) and Carling (Moselle), and Dislaub alcohol distilling and solvent processing plants in Buchères (Aube).

The IRSN also provides technical support to the ministry for the Environment. It actively participates in the focus groups set up by the ministry regarding prevention plans for technological risks, toxicological reference values or sectorial aspects (chlorine, ammonia, flammable liquids, fine chemicals, etc.).

Finally, in 2005 the Institute completed a probabilistic study regarding the risk of gas explosion in a liquid petroleum gas storage facility. The results obtained were presented to the ministry and the whole gas profession.

Services not related to statutory requirements

STUDY OF THE RADIOACTIVITY OF EFFLUENTS FROM THE TOURS TREATMENT PLANT

Beyond the regulatory aspects, the IRSN is regularly called on by urban waste water treatment network operators to assess the radioactive marking relating to acts of nuclear medicine and the corresponding health impact in water treatment plants. In 2005, the town of Tours ordered such a study. To do so, continuous gamma measurements on waste water were carried out, along with integrated gamma dose flow measurements, in a treatment station, in six specific premises and a control zone. The significant values recorded in the waste water at the entrance to the plant were used to quantify transit times, the effect of dilution of the urban network and the flows of radionuclides. These values complied with the recommendations of the DGS/DHOS circular no. 2001/323 of 9 July 2001 regarding the management of effluent and treatment waste contaminated by radionuclides. The dosimetric impact calculated majoritairely is very low, mainly due to the low half life of metastable technitium 99, the main radionuclide discharged.

SAFETY OF PLANTS, TRANSPORT AND DISMANTLING

Criticality risk studies related to the use of fissile materials in nuclear installations or during transport,

[FOCUS]

Sale of low-activity standard sources

The preparation of standard sources requires rigour and precision. Here a grid-type crushing system is used to perfectly homogenise the sample to be prepared.

To meet the demand for the supply of low-activity standard radioactive sources, the IRSN obtained authorisation from the DGSNR in June 2005 "to hold for distribution, use, sale, import and export, sealed and non-sealed radionuclide sources".

1,000 to 2,000 sources, concerning more than 50 different radionuclides, are prepared every year for the internal needs of the Institute, in various forms:

- sources in liquid or gel form, occasional deposit or deposit on a filter, a cup or a stainless steel disk, electroplated sources;
- natural samples recharged with radioactivity;
- standard solutions;
- tracer solutions for marking of samples and determination of chemical separation yields for samples prior to measurement.

Thus, the environmental radioactivity measurement laboratories can obtain the standard sources from the Institute, specific to low-activity measurements.

requires the use of qualified calculation software. In collaboration with industrialists, the IRSN is developing the CRISTAL criticality package to enable such studies to be carried out.
It is making this tool available to a number of users for whom installation support is also offered.

STUDIES REGARDING NIGERIAN AREVA MINING SITES

In 2005, the IRSN, at the request of the company Areva, carried out two studies relating to the uranium mines operated in north Niger by the companies Cominak and Somaïr.

Partly based on a mission on site, these two studies consisted of assessing the environmental radioactivity monitoring networks around the sites and evaluating the dosimetric impact of the mines on the population. The impact of the recovery and domestic use of contaminated scrap iron from the mines was also examined. The results, published on the IRSN website, showed that the monitoring networks set up by Areva around the two mine sites generally comply with the requirements applicable to the storage of uranium waste in France.
Nevertheless, improvements were deemed necessary to specify or reduce the exposure of some categories of people. The recommendations made led Areva to call on the Institute once again to take the samples and analyse the groundwater supplying the water distribution network, so as to be able to assess more accurately the impact due to the consumption of drinking water.

[FOCUS]

Support services for the users of the CRISTAL package

Modelling using the CRISTAL package.

The CRISTAL package is used to carry out all types of calculations required in criticality risk studies. In order to ensure a high level of quality of the criticality studies conducted using this package, significant technical support and training is provided to users when it is distributed, coordinated by the IRSN.

The IRSN support services include:
- supply and validation of the installation at the customer of the codes and tools developed by the IRSN;
- assistance in the use of these codes and tools in the form of a hotline;
- corrective and evolutive maintenance, based on a computerised call-out management tool, directly accessible to users via the Internet;
- publication of information regarding qualification of the "standard method" of calculation (APOLLO 2-MORET 4);
- management of a website reserved for users, enabling them to access all technical documentation, put in requests for intervention and remain informed of the follow-up to their requests, and to download the various versions of the codes and tools developed by the IRSN;
- training sessions conducted at the IRSN or at the National institute of nuclear sciences and techniques, in collaboration with the developers.

In 2005, the IRSN installed version 1.0 of the package in 15 facilities belonging to the CEA, Areva and EDF. The Institute also replied to 262 calls and processed 129 requests for intervention for the two versions supplied of the CRISTAL package.

RADIOECOLOGY SERVICES

The IRSN provides measurement and study services in the radioecological field for industrialists and public authorities.

Radioecological follow-up of nuclear power plants

Since 1991, an agreement between the IRSN and EDF concerns the determination of levels of radioactivity around nuclear power plants. This is EDF's willingness to go further than strictly statutory obligations, and for this purpose to measure the very low concentrations of artificial radionuclides in the land, rivers or seas surrounding its installations. This monitoring also enables questions to be answered from the public authorities or the company as regards protection of the environment and the population.

Currently, the agreement comprises three sections: annual radioecological monitoring around each nuclear power plant, ten-yearly reports and a research part into the behaviour of specific radionuclides such as tritium and carbon 14.
Today, the data acquired enables the Institute to draw up a report of the environmental consequences over 20 years of the operation of nuclear power plants. The radionuclides present in measurable quantities (caesium 137, plutonium, etc.) in the soil, wild plants and agricultural production, come almost exclusively from fallout from atmospheric testing of nuclear weapons and from the Chernobyl accident. Only a very low but significant environmental marking by carbon 14 from plant discharges was revealed.

Radioecological follow-up at the Tricastin power plant (Drôme) by sample taking.


Validation of the DISPRO calculation code requires a large number of samples collected in the field to be measured, to compare the results to those obtained by modelling.

Survey of eating habits around Pierrelatte

From the summer of 2004 to the spring of 2005, the IRSN piloted a survey ordered by Cogema into the eating and consumption habits of the populations living around the nuclear site in Pierrelatte (Drôme). This survey aims at better taking account of local practices to assess the doses linked to discharges from site installations. The survey was conducted on 80 households. In particular, the results show that a population exists, which is still significant in these semi-rural zones, who produces a major proportion of the food it consumes.

Studies around the Cogema site in La Hague

The services contract of several years' standing between the IRSN and Cogema has been extended in 2005 to cover two topics concerning the irradiated fuel processing plant in La Hague (Manche). A first

study was conducted to validate the DISPRO calculation code used to predict the dispersal of radionuclide releases in the Manche area of France from the plant. To improve the knowledge of these factory discharges, a second study was conducted concerning the granulometry of aerosols from the UP3 facility and on the assessment of deposit rates of aerosols released into the environment by the facility.

Transfers of tritium and carbon 14 into the water and the atmosphere

In 2005, the CEA asked the Institute, as part of a sub-contracting contract between the CEA and EDF, to conduct experimental studies to assess the transfer flows from water to the atmosphere of tritium and carbon 14 downstream of nuclear power plants along the Loire.

Replies to tenders

About 10 projects proposed by the Institute on the subject of the fate and effects of radioactive contaminants in the environment, were chosen in 2005. These projects, conducted in collaboration with other research partners, reply to various calls for tender from various public organisations (Andra, Seine-Normandy water agency, Haute-Normandie region, Provence-Alpes-Côte d'Azur region, ministry for Research, ministry for the Environment, etc.).

SERVICES CONCERNING RADON

Radon measurements in prehistoric caves

Following the discovery of high concentrations of radon in the Chauvet-Pont-d'Arc cave (Ardèche), the ministry for Culture asked the IRSN to conduct measurements of the radon activity concentration in the caves under its management, to asses the exposure of the people working in these caves (guides, researchers, etc.).

Due to the extremely humid atmosphere in these caves, a special method was defined to best characterise the radon contents and to determine the most suitable instrument.

Following a protocol validation phase in five caves (Chauvet, Niaux [Ariège], Lascaux, Font-de-Gaume and Combarelles [Dordogne]), the IRSN proposed a protocol systematically applicable to this type of cave.

Radon and thoron measurements in the premises of the French Navy

In 2005, for the ministry of Defense, the IRSN conducted measurements to characterise, from a radiological point of view, the inner atmosphere in some underground premises. Quantification of radon and thoron daughters by integrated measurements enabled the exposure of the personnel working in these areas to be estimated.

Devices to measure radon concentration in a cave.

MODELLING OF FACILITY VENTILATION

The premises of nuclear installations in which there is a risk of dispersion of radioactive materials or contaminants requires ventilation and monitoring of their atmosphere by air sampling.

The most homogenous renewal possible of the air in these areas is sought in order to prevent any local accumulation of radioactive aerosols or pollutants. The IRSN develops and installs techniques to measure ventilation performance and transfers of the associated radioactive materials or pollutants *(see Focus*)*.

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[FOCUS]

Ventilation performance - transfer of pollutants

Gas and particulate tracing devices used by the IRSN.

In 2005, the IRSN carried out *in situ* measurements at the request of nuclear operators or industrialists to check the ventilation performance in the premises concerned, in particular, the absence of low ventilated zones and the relevance of installing air sampling monitoring devices (APA, explosion meters, etc.).

Two complementary approaches were used. The first consisted of measuring the evolution over time in the air extracted from the area of the concentration of a gas tracer (helium or sulfur hexafluoride) continuously injected by blowing.
The second approach consisted of characterising the transfer of a gas or particulate pollutant (simulated by an aerosol of sodium fluorescein of given diameter) from a source point S to any point M in the premises.

In addition, the IRSN teams use similar tracing techniques for other applications (flow measurement, barrier sealing measurements, verification of the representativity of a sample in a chimney, etc.) in the field of containment and filtering of aerosols and pollutants.

DOSIMETRIC SERVICES

Biological dosimetry

In 2005, the IRSN's biological dosimetric laboratory, the only one in France recognised for this type of expert assessment, carried out eight estimations of individual doses in reply to requests from general practitioners or occupational physicians: two retrospective estimates and six for suspicious recent irradiations in a professional setting. The estimate of the doses received using biological dosimetry is based on the observation of chromosomal aberrations (dicentric) formed in the lymphocytes of the people concerned.

The retrospective estimates concerned people who had consulted a physician for various pathologies. In both cases, the number of chromosomal aberrations observed was greater than that for the non-exposed population taken for reference.
For recent suspicious irradiations, the doses estimated by biological dosimetry did not differ significantly from zero, for various reasons: no real exposure despite the positive reading on the dosimeter; the dose to the whole body is too low to be measured by biological dosimetry; the sensitivity of the traditional biological dosimeter is not suitable for cases of heterogeneous irradiation.

Numbering of chromosomal aberrations.

Geometric modelling for the calculation of effective dose.

Assessment of the exposure of the public and workers

The IRSN is regularly called on by companies or institutions to assess the doses received in specific contexts.

In 2005, studies were carried out to assess the doses which may have been received:

- by the public during a cure at a spa, due to the radioactivity present in the water;
- by people living in a chalet built with wood from Belarus;
- by the employees of a waste water treatment plant possibly containing radionuclides in particular from radiotherapies.

Dosimetric assessment following an incident in Paluel

In July 2005, the IRSN conducted a dosimetric reconstitution at the request of the occupational physician at the EDF power plant in Paluel (Seine-Maritime).

An incident had occurred during the cleaning of a steam generator and several workers had handled a radioactive metal part. The IRSN conducted calculations of the dose to the skin by considering several plausible scenarios (part in contact, gloves worn).

Although wearing gloves protects almost entirely against beta radiation, the dose rate absorbed remained high because the contribution of photons was high.

The reconstitutions conducted by EDF showed that the exposure time had been short. Consequently, the dose equivalents to the skin calculated are far lower than the annual limit of 500 mSv.

RADIOLOGICAL PROTECTION IN THE MEDICAL FIELD

The IRSN is frequently called on by the medical professionals to participate in ways to better understand the exposure of health personnel in normal working conditions. The Institute's contribution can go from simple provision of dosimeters to a complete on-site study. Recent changes in legislation, and in particular laws governing operational dosimetry, are creating growing interest in studies on workstations and zoning.

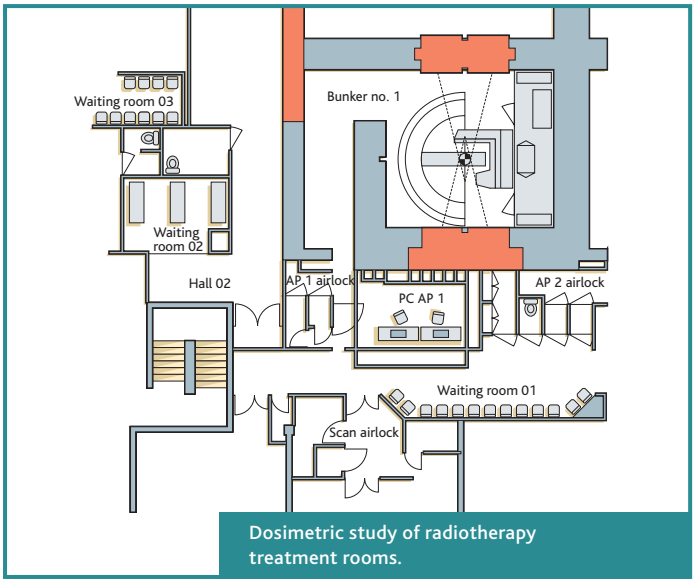
The sectors most interested in these services are radiology, and more specifically interventional radiology, and nuclear medicine. In general, special attention is paid to all activities where the operator is close to the patient and risks receiving high doses. Work station studies have shown that, in the most unfavourable situations (on the liver in interventional radiology), the doses to the hands and feet are of the order of 250 mSv/year, or half the dose limit. In nuclear medicine, the most critical situations occur during the handling of fluorine 18.

Monitoring of workers exposed to asbestos

As part of post-professional monitoring of workers exposed to asbestos, the IRSN was responsible for assessing the doses received during scanner examinations associated with this monitoring. A report was sent to the ministry for Labour in October 2005. To conduct this assessment, 187 scans were considered with an effective average dose per examination of 3.9 mSv. This dose is less than the diagnostic scan reference level for a standard lung examination, which is of the order of 8.5 mSv.

Radiological protection in radiotherapy facilities

In 2005, the IRSN with the support of the DGSNR launched a study to answer the concerns of radiotherapists or radiophysicians. Indeed, the Institute is regularly consulted for its opinion on projects to built or renovate radiotherapy rooms. To these requests have recently been added the concerns of the users of linear accelerators, con-



Dosimetric study of radiotherapy treatment rooms.

cerning protection against neutrons produced by devices of over 10 MV. This work is used to understand the importance of the configuration of the room and of the type of device used in radiotherapy.

Dosimetric assessment for new radiology technologies

In 2005, at the request of the professionals concerned, the IRSN participated in assessing new 3D imaging techniques used in dental radiology. The doses were compared to those of similar examinations conducted using a scanner. For the "Newtom" system, doses to the skin and the salivary glands are respectively lower by a factor of two and three than those of a traditional scanner examination.

For the "Accuitomo" system, doses to the skin and salivary glands are comparable to those received from a traditional scanner examination whose acquisition parameters have been optimised.

Exposure of pregnant women

In response to requests from radiologists or gynecologists, the IRSN conducted in 2005 dosimetric assessments for 54 pregnant patients who had undergone one or more radiological examinations. The corresponding examinations are divided between traditional radiology (26 cases), scanning (26 cases), nuclear medicine (one case) and radiotherapy (one case). The estimated doses received by the fetus range from a few mGy (24% of cases) to 30-51 mGy (5.5% of cases). 51 cases were studied in 2004 and the doses were similarly distributed.

In relation to international recommendations and in particular those in publication 84 of the ICRP, all these doses are lower than the value of 100 mGy, the limit above which there may be prejudice to the fetus, the extent and nature of which depend on the dose and the stage in the pregnancy.

OPERATIONAL RADIOLOGICAL PROTECTION SERVICES

The IRSN's services in operational radiological protection cover all entities possessing or using ionising radiation sources, mainly in France but also in other countries. Services correspond to consultancy, study, expert assessment or radiological analysis (sealed or non-sealed sources, polluted sites, equipment or installations).

Interventions may also be carried out, in particular in a degraded situation (making sources safe, detection and measurement of radon). In 2005, the Institute provided 112 services, of all types, to public and private establishments and private individuals.

Some interventions require the use of IRSN remote tools. Here the robot Romain.

[FOCUS]

Radiological expert assessment of a device for import into France

The equipment assessed by the IRSN in Australia prior to its import into France.

The import company PLCD asked the IRSN to carry out a radiological expert assessment of a device to analyse the chemical elements in cement, manufactured in Australia and using a neutron source of californium 252 of about 1 GBq. An IRSN team went to Adelaide to the premises of the Scantech manufacturer to conduct radioactivity measurements. It was able to assess the risk of exposure to ionising radiation and check the various safety and protection systems.

The expert assessment determined the specific precautions to be taken when installing equipment in cement factories and proposed improvements to protection, safety and signalling.

[FOCUS]

Stabilisation of the sarcophagus of the damaged reactor at the Chernobyl power plant

The IRSN is continuing its activity of assistance to the Ukrainian safety authority.

Stabilisation work on the current structures of the sarcophagus surrounding reactor no. 4 continued and were intensified at the Chernobyl site during 2005. Started in 2004, this work should be completed towards the end of 2006.
In parallel, the assistance to the Ukrainian safety authority provided by the IRSN was continued by providing support to the Ukrainian technical support organisation (SSTC) to assess a large number of safety dossiers sent in by the operator. These safety dossiers concern various domains in the project: stabilisation work, foundations, design of the new sarcophagus, integrated and automated monitoring system, *a priori* assessment of exposure to radiation during the work, legislation to limit this worker exposure, strategies for managing radioactive waste, etc.

[FOCUS]

Riskaudit

Riskaudit is a European group of economic interest (EGEI) founded in 1992 by the IPSN and the GRS to co-ordinate joint international projects. Since its founding, Riskaudit has managed more than 100 projects involving its two parent establishments and other European and American technical safety organisations, in the context of programmes to provide assistance to Eastern European countries in nuclear safety, financed by the European Commission and the European Bank for Reconstruction and Development (EBRD).
Riskaudit has its headquarters in Châtillon (Hauts-de-Seine) and two permanent offices in Moscow (Russia) and Kiev (Ukraine).

COLLABORATION WITH EASTERN EUROPEAN COUNTRIES

Nuclear safety in Eastern European countries is a major target for the IRSN's international action in partnership with other European technical safety organisations and those of the countries concerned.

Collaboration with Eastern European countries occurs via the development of regulatory contexts, transfer of calculation codes and training in their use, but above all via the conducting of safety reviews.
These reviews concern the definition of safety objectives or requirements, the determination of necessary improvements, assessment of the corresponding improvement programmes, and analysis of the detailed solutions offered by the operators. In this context, the IRSN participated in about 40 projects in 2005, in particular in safety review regarding RBMK reactors in Lithuania and Russia, and VVER reactors in Ukraine.
This co-operation is mainly carried out in the context of contracts managed by Riskaudit, a subsidiary of the IRSN and GRS, and financed by the European Commission (PHARE and TACIS programmes) or by the EBRD.
Co-operation in this part of the world is seeing new developments with the setting up in Russia and, in the near future, in Ukraine of the "Global Partnership Against the Spread of Weapons and Materials of Mass Destruction" adopted by G8 in 2002.

Expert assessments as part of the G8 global partnership

[FOCUS]

France is a key player in the G8 global partnership, decided during the Kananaskis summit in 2002, in particular in the field of the fight against the spread of weapons of mass destruction and against terrorism.

Within this framework, in 2005 the IRSN participated in preparing several technical support projects for the radiological protection or safety authorities concerned:

- "RTG legislation", service to improve Russian legislation applicable to the dismantling of radioisotope thermoelectric generators (RTG);
- "Kalinine", assessment of the improvements planned by the operator for protection against fire of the Kalinine power plant (Lithuania);
- "AÏDA MOX", setting up of legislation adapted to the elimination of Russian military plutonium in the form of MOX fuel.

Emergency shutdown system for the reactor no.2 in the Ignalina power plant

[FOCUS]

In 2005, the IRSN participated in a PHARE project on a safety review of the new emergency shutdown system on reactor no. 2 of the Ignalina nuclear power plant (Lithuania), assisting the Lithuanian safety authority.
In October 2005, the operator of this nuclear facility completed installation of this new emergency shutdown system.
It includes two independent sub-systems, each able to shut down the reactor if necessary.

Key figures **2005**

Key figures 2004

132 technical reports related to the safety of defence-related installations and activities

103

13 meetings of safety commissions and small groups of experts

9

4 crisis exercises related to the safety of defence-related installations

3

183 inspections related to the control of nuclear materials

198

1 crisis exercise related to the security of installations

1

NUCLEAR DEFENCE EXPERTISE

In application of the decree relating to the IRSN dated 22 February 2002, the Assistant Director General in charge of implementing the Institute's defence-related missions, has a specific division, the DEND, (Division for nuclear defence expertise). It carries out expert assessments, inspections, studies and research regarding the safety and radiological protection of defence-related activities and instal lations, protection and control of nuclear and sensitive materials and protection of nuclear installations and transport of radioactive and fissile materials against malicious acts.

Assessment of the safety of military nuclear systems, secret basic nuclear installations and defence-related transport

TECHNICAL SUPPORT WITH REGARD TO NUCLEAR AND RADIOLOGICAL RISK

OPERATIONAL SUPPORT IN CASE OF CRISIS OR RADIOLOGICAL EMERGENCY

In 2005, the IRSN examined the safety of defence-related installations and transport, based on dossiers provided by the operators, and sent the corresponding reports to the delegate for safety and radiological protection of nuclear defence-related installations and activities (DSND). The installations concerned may be in the stage of design, operation, definitive shutdown or dismantling.

Activities concerning defence-related laboratories and plants

In 2005, the IRSN examined the safety of installations operated by the CEA (Division for military applications) or by Cogema, using procedures required to supply and manufacture weapons and manufacture fuel for naval propulsion nuclear reactors.

The IRSN examined the safety of radioactive waste management in the CEA Valduc centre (Côte-d'Or) based in particular on the study of "waste" and annual "waste plans" presented by the operator. This assessment dealt with:

- "waste zoning" of installations;
- operator's waste management strategy;
- perspectives for the treatment of waste from the Valduc centre;
- changes in the types and quantities of waste produced by the site.

The operator's dossier and the associated IRSN assessment report were used for the meeting of the Safety commission in charge of waste management (CSGD) on 26 May 2005.

General view of Marcoule - in the centre of the UP1 plant.

The IRSN monitored the Cogema establishment in Marcoule (Gard) and the installations on this site. Within this framework, the Institute transmitted reports on the following:

- waste storage and conditioning installations, in particular these reports dealt with versatile interim storage, implementation of storage pits and review of the safety of the alpha waste storage and conditioning site (IECDA). The corresponding reports were presented to the CSGD and to the Commission for the safety of laboratories and plants (CSLU);
- general safety provisions for secret basic nuclear installations (INBS);

Transport of radioactive materials by road tanker.

- operations planned as part of continuing shut-down and dismantling of the UP1 plant and the decanning workshop;
- evacuation, after reconditioning, of rod cartridges to Cadarache (Bouches-du-Rhône);
- storage of irradiated fuel rod cartridges;
- implementation of a station to measure the activity of technological waste;
- five-year extension of storage of waste from definitive shutdown operations of the UP1 plant.

The IRSN monitored the Cogema establishment in Pierrelatte (Drôme) and the installations on this site. In this respect, the Institute transmitted reports on the following:

- start of operation of the P35 storage park for uranium-bearing materials;
- dismantling operations on annexes of gaseous diffusion plants (GDP);

For the Istres airbase, and as part of the creation of a new INBS, the IRSN provided a report on the civil engineering safety demonstration regarding earthquakes.

Activities regarding the transport of defence-related radioactive materials

A new type of transport package for radioactive waste, enabling materials of high-level activity to be transported by air, has been under development since 1996 by the CEA (Division for military applications - DAM). This type of packaging must withstand the accident conditions representative of air transport, without significant loss of containment and without significant increase of dose rates outside the package. The IRSN continued its development and, in 2005, investigated the corresponding safety dossier. In-depth technical exchanges took place between the CEA (DAM) and the IRSN, in particular concerning the mechanical behaviour of the packaging during a high-speed impact. The IRSN's report on the safety of this package was presented to the Transport safety commission (CST).

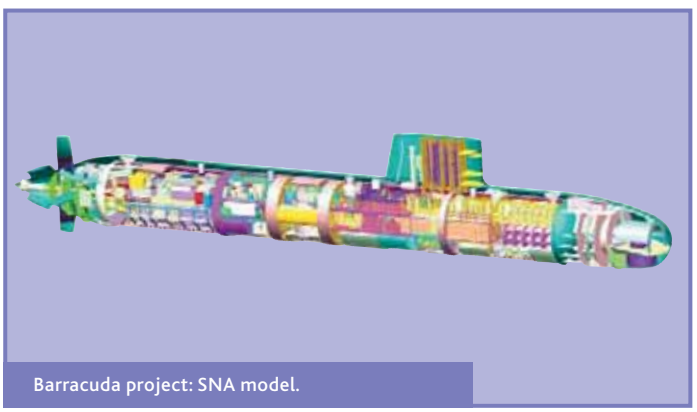
In addition, a review concerning radioactive material transport legislation, takes place every two years with proposals and modifications from the Members States and international organisations (ISO, EEC, etc.) submitted to the IAEA. 40 proposals were accepted by the IAEA's legislation review committee and sent for comments to the Member States and international organisations. The IRSN provided a report on 11 proposals which it judged the most important for safety and presented this report to the Transport safety commission (CST) at the request of the DSND.

Finally, the IRSN appraised dossiers concerning internal transfers at the Pierrelatte, Cadarache, Marcoule and Valduc sites, and packaging dossiers for transport on public roads.

Activities related to naval propulsion reactors

The expert assessments conducted by the IRSN in 2005 concerned the design, operation and dismantling of installations and in particular, naval propulsion reactors.

As regards design, 2005 was marked by continuing



Barracuda project: SNA model.

Saphir, a French nuclear attack submarine (SNA).

investigations into the preliminary safety report on new-generation Barracuda nuclear attack submarines (SNA), the object of two meetings of the Reactor safety commission. Following the investigation which should be completed in the first half of 2006, the DSND will decide whether or not to authorise the first of this type of boiler.

As regards operations monitoring, work in 2005 in particular dealt with the safety review of SNA, the first "major overhaul" of *Le Triomphant*, a French nuclear-powered ballistic missile submarine (SNLE), and the 2004 operating report for onboard nuclear boilers.

Safety review of Rubis-type SNAs: In April 2005, the IRSN presented the Reactor safety commission with its report on the general approach of the Rubis-type SNA safety review, and on the method to study accident scenarios. The technical investigation into the safety review of SNAs, the first vessel of its type which was launched in 1983, should be extended until 2008. A safety review mainly consists of examining the conformity of the installations to their initial safety standard and the main events occurred during operation, completed by a repeat of the safety demonstration taking into account the requirements for a new installation. This exercise may lead to modifications being defined, which would aim to strengthen the overall safety of the installations.

Major overhaul: 2005 was also marked by the first exhaustive examination of the work and inspections conducted during a major overhaul of a nuclear-powered vessel. It consists of analysing the maintenance policy and the associated organisation implemented during such a phase, but also the significant safety modifications made to the installations, taking account of requests made by the DSND, the scope and the results of inspections carried out on various containment "barriers", and the programme and methods to requalify the nuclear boiler room and support installations.

Annual operating review: The annual examination of the operating review of onboard nuclear boilers includes an analysis of the incidents which occurred and significant events in terms of training, organisation, waste management and monitoring of reactor evolution. In 2005, this examination was completed by an operating reliability assessment of the electricity production equipment on SNLEs such as *Le Triomphant*.
As regards dismantling, 2005 was mainly marked by reviews regarding the definitive shutdown of the boiler on the SNLE *L'Indomptable* and its support installations, and dismantling methods.
Finally, the IRSN also analysed two especially important safety dossiers:

Le Triomphant, a French nuclear-powered ballistic missile submarine (SNLE).

- the scenarios proposed by the operator to draw up the special intervention plan regarding the port of Toulon (Var);
- the conditions for carrying out statutory resistance tests on the main primary circuits of onboard nuclear boilers.

Activities related to radioactive sources

In 2005, as part of the gradual implementation of new legislation regarding radiological protection, the IRSN listed about 20 installations whose radioactive sources are henceforth inspected by the DSND. This number should change seeing as inspection of installations authorized by the CIREA (Interministerial commission on artificial radio-elements) prior to 2002 will be transferred to the DSND. For these installations, the IRSN monitors movements of sources by issuing the required packages and by recording them in the national inventory.

Activities regarding internal emergency plans (PUI)

In 2005, the IRSN sent technical reports concerning PUI reviews for installations classified as secret. They concerned:

- the operational part of the PUI of the Cogema facility in Marcoule;
- the accident situations used to draw up the PUI for the CEA Valduc facility.

The latter expert assessment consisted of examining all accident situations chosen, then, for each situation, assessing detection and alert means, intervention means, discharges and the radiological consequences calculated by the operator.

In general, the IRSN is finding it difficult to cope with the increasing workload resulting from updating the PUIs of defence-related nuclear installations, as those of civilian installations.

Crisis exercises

In 2005, the IRSN participated in four national crisis exercises concerning secret basic nuclear installations (INBS):

- the CELESTIN reactors in the Cogema Marcoule facility;
- the Saint-Dizier (Haute-Marne) airbase;
- a workshop at the CEA Valduc centre;
- an SNLE at the Île-Longue base.

These various scenarios were used to test IRSN relations with the safety authority (DSND) and with the operators of the installations concerned.

Protection and control of nuclear and sensitive materials

TECHNICAL SUPPORT WITH REGARD TO NUCLEAR AND RADIOLOGICAL RISK

DEFINING AND IMPLEMENTING NATIONAL AND INTERNATIONAL RESEARCH PROGRAMMES

There are several aspects to the protection and control of nuclear and sensitive materials: physical protection, monitoring of and accounting for nuclear materials, tracking of transports and applying international controls on the non-proliferation of chemical and nuclear weapons.

PHYSICAL PROTECTION OF NUCLEAR MATERIALS

Expert assessment and inspection activities

The IRSN places its technical expertise at the disposal of public authorities to assess the efficiency of physical protection measures adopted or proposed by nuclear operators and holders of nuclear materials. In this capacity, the IRSN analyses the reports required by legislation and organises technical meetings with operators as part of its investigations.

In addition, on behalf of the High Civil Defence Servant (HFD) at the ministry for Finance, some IRSN agents carry out inspections in installations holding nuclear materials, in order to check *in situ* that protection and control provisions against loss, theft or hijacking of nuclear materials and protection of installations against malicious acts, are in place and operational.

For this purpose, the Institute carried out 51 inspections and, during 2005, processed about 130 requests to analyse dossiers provided by operators and holders around 100 of which gave rise to an analysis report.

During these inspections, the Institute carried out *in situ* measurements of the physical characteristics of protection systems.

56 support missions
carried out by international inspectors to control nuclear and sensitive materials
(32 in 2004)

42 participations
in national and international focus groups
(54 in 2004)

Assessments carried out during inspections

The IRSN assesses the performance of the physical protection systems installed by nuclear operators to prevent any theft or hijacking of nuclear materials. During 2005, several sites were thus assessed, with particular emphasis on electrical fencing. This action will continue in 2006. Tests and assessments concern both verification of the technical recommendations of the equipment manufacturers and the suitability of this equipment to the objective sought.
Assessments concern in particular the two functions "detect" and "delay".

Physical protection barrier.

Detect
Detection leads to a yes or no answer, and if necessary, calls in the response forces. To analyse this function in-depth, the IRSN successively examines the physical components of detection (with their operating principles), transmission of information to a security post and the taking into account of the information by the agent on duty.

These three steps are assessed by field tests to take account of the specificities of the installations (distances between buildings, location of the security post, surface area of the zone to be monitored, etc.). For electrical fencing, several break-in detection systems are used, some of which require thresholds to be set. It is essential to ensure that the adjustments made by the operators properly detect a break-in attempt.

Delay
This function, for electrical fencing, is based on the association of a physical barrier (the fence) with an electrical pulse signal. The high voltage of the electrical signal, tested during on-site tests, ensures the repel function.

MONITORING OF AND ACCOUNTING FOR NUCLEAR MATERIALS

Expert assessment and inspection activities

At the request of the High Civil Defence Servant (HFD) at the ministry for Finance, the IRSN examines the provisions made by operators and holders in terms of monitoring of and accounting for nuclear materials held in installations, in particular in order to:

- have precise, quantitative and qualitative information on all the nuclear materials that enter and leave the installations;
- track the materials, i.e. always know where they are located, what they are used for and the operations they undergo (movements, transformations, etc.);
- check that the actual stock of materials held corresponds to the accounting figures that operators are compelled to keep updated.

The IRSN suggests any corrective measures it deems necessary, in particular regarding risks of theft, loss or hijacking of nuclear materials. It then ensures that the requests from the HFD are properly met, and reports to him.

In addition, on behalf of the HFD, some IRSN agents carry out inspections in installations authorised to hold nuclear materials, to ensure that applicable standards regarding detention of these materials are met.

For the record, legislation distinguishes between installations subject to a prior authorisation and installations subject to a prior declaration, depending on the nature and quantity of materials held.

Within this context, during 2005, the IRSN conducted:

- 128 analyses of dossiers sent in by operators which required around 40 technical meetings and produced 113 analyses of inventory reports on nuclear materials;
- 79 inspections at operators subject to authorisation. In addition, the Institute carried out about 20 technical inspections of installations subject to a prior declaration.

Changes in accounting

The new Euratom 302/2005 rule came into force on 20 March 2005. The IRSN, who for the HFD fixes the rules for declaring counts of nuclear materials, centralises the accounting data transmitted by holders and sends the declarations to the European Commission, is directly concerned by changes introduced by the new rule. These changes concern the formalism of the accounting reports and documents sent to the Commission, and extension of European control to nuclear industry waste which until now, was subject to national control, and the supply of additional information.

The IRSN's action included monitoring of the negotiations prior to publication of the 302/2005 rule, presentation of the text to French operators and an impact study on the nuclear material management in France. Following this study, two focus groups were organised by the Institute with representatives of French nuclear operators. The first dealt with changes necessary in the short-term. Its work led to decisions to modify the national

accounting computer system to enable operators to meet the new obligations, regarding accounting for waste, from July 2006.
The second focus group dealt with content changes to be implemented before March 2008. It aims to harmonize the modes of application of national and European rules, and plans a significant change in operators' accounting systems. This change also concerns the formalism of the national accounting declarations, which include the additional information required by the 302/2005 rule. This focus group's decisions will enable specifications to be drawn up, required to implement modifications to the French accounting system and the national accounting computer system planned for 2006-2007. The statutory standard codifying national accounting declarations also needs to be updated and this will be done in 2006.

TRANSPORT OF NUCLEAR MATERIALS

Within the IRSN, the Operational transport section (EOT), on behalf of the HFD from the ministry for Finance, carries out operational missions in the field of protection and control of nuclear materials during transport. The road transport means used for these transports are subject to an approval procedure from the Minefi, in which the IRSN participates by assessing the design dossiers, monitoring production and conducting periodic inspections.
Thus, the EOT managed and monitored 1,558 transports in 2005.
Among these should be mentioned a particularly sensitive international transport the first phase of which started in 2004: transport of nuclear materials for manufacture in France of MOX fuel for a reactor in the United States (EUROFAB project). The EOT investigated dossiers describing physical protective measures for nuclear materials during their transfer from the Cadarache (Bouches-du-Rhône) plutonium technology workshop (ATPu) to the MELOX facility, then from there to the La Hague facility (Manche), and finally, during loading onto the ship for transport to the United States.
The EOT also carried out real-time satellite monitoring of all these movements 24 hours a day, until the ship left the French territorial waters (*see Focus opposite*).

Container of experimental irradiated fuel elements.

INTERNATIONAL CONTROLS ON NON-PROLIFERATION

Some international treaties to fight proliferation of nuclear and chemical weapons of mass destruction, implement inspection systems. In France, the IRSN provides assistance and technical support to authorities in charge of monitoring these inspections.
The inspection systems implemented by the Treaty of Non-Proliferation, the Treaty of Rome or the Chemical Weapons Convention may be different but they all involve international officers checking, in declared facilities, the information transmitted by States to international inspection bodies (IAEA, Euratom, OPCW).
Within this framework, the IRSN acts on behalf of French authorities, collecting and preparing the French declarations to inspection bodies.

The Institute is also in charge of ensuring the smooth running of international inspections in French nuclear or chemical facilities. For this purpose, it prepares the inspections, accompanies the inspection team as the representative of the French authorities and ensures the practical arrangements of the inspection are followed.

In its capacity as technical support, the IRSN analyses the technical documentation to be submitted by those being inspected, before it is sent to the inspection body. It assists French authorities by analysing and keeping up with changes to national or international regulations relating to the fight against proliferation. When necessary, it takes part in interministerial work and joins groups of international experts set up by the Organisation for the Prohibition of Chemical Weapons (OPCW) or IAEA.

Chemistry

During the past year, the IRSN prepared and sent to the ministry for Foreign affairs, for the OPCW:

- the declaration of 2004 activities on the 144 French chemical facilities listed;
- the declaration of the activities planned on these sites in 2006.

The IRSN accompanies the eight inspections that the OPCW ordered in chemical facilities in the French civilian sector. None of these inspections required any follow-up by the OPCW.

The Institute also participated in all the projects of the OPCW expert groups aiming to propose practical methods of inspecting civilian installations around the world.

Nuclear

In 2005, the IRSN prepared and transmitted to the European Commission:

- more than 160,000 lines of operations declaration on nuclear materials;
- more than 500,000 lines of physical stock declarations;
- more than 650 reports prior to import or export.

Samples for the Euratom inspection.

[FOCUS]

Protection and control of nuclear materials during the EUROFAB operation

Sea transport of nuclear materials.

Manufacture by Cogema of four MOX assemblies with plutonium for use in American power generating reactors (EUROFAB operation) involved the IRSN on several levels.

During 2004 and 2005, the Institute was called upon to:

- check authorisations and approvals of transport equipment, approve transport plans and monitor land and sea transports, including the highly publicized one in October 2004 between La Hague and Cadarache, mentioned previously;
- assess and inspect physical protection and detection systems for nuclear materials;
- in terms of monitoring of and accounting for nuclear materials, analyse the adequacy of the preparatory campaign to restart the ATPu manufacturing line in Cadarache, the relevance of reception checks of foreign plutonium and in-process controls, and the validity of material analysis methods used;
- study the behaviour of the FS47 package in the event of a malicious act.

Preparation of the annual declaration as part of application of the additional French protocol.

The Institute prepared and sent to the Euratom technical committee:

- provisional programme of activities for declared French nuclear facilities;
- the list of some 250 French holders of low quantities of nuclear materials (and the condition of their stocks). It also prepared and sent to the French governor to the IAEA:
- monthly and six-monthly accounts of stocks of nuclear materials to be sent to the IAEA;
- the monthly and six-monthly accounting reports related to the international transfers of crude materials and ores;
- draft annual declaration of France on its research and development and co-operation activities with States not equipped with nuclear weapons (as part of application of the additional protocol to safeguard agreements);
- draft quarterly declarations of France to the IAEA, regarding export of equipment or non-nuclear materials (within the same context).

The Institute accompanied 48 inspections by the European Commission as part of inventory controls (35) and checks of dossiers known as "basic technical characteristics" of installations (13). The IRSN's activities in 2005 were considerably influenced by the review of the Euratom 302/2005 rule and by the European Commission's decision to significantly modify its way of inspecting installations. The review of the Euratom rule requires that inspections be extended to waste. The decision aims to increase the qualitative dimension of the inspection, in particular by means of audits of the operators' management systems for nuclear materials.
In this context, the IRSN participated in many discussions with the services of the European Commission and with French nuclear operators.

Protection against malicious acts

The arrangements chosen internationally to fight against terrorist or malicious acts strengthened the need, already identified nationally, to improve legislation regarding the protection of nuclear installations, radioactive sources or transport of nuclear materials against malicious acts.

TECHNICAL SUPPORT WITH REGARD TO NUCLEAR AND RADIOLOGICAL RISK

DEFINING AND IMPLEMENTING NATIONAL AND INTERNATIONAL RESEARCH PROGRAMMES

Improving regulatory texts

In 2005, the IRSN participated in work undertaken to strengthen and harmonize defence code legislation regarding the protection of nuclear materials against the risks of theft or hijacking and that regarding the protection of nuclear materials and installations against the risks of sabotage. Thus, the IRSN participated in writing up the draft decree to apply articles L.1333-1 and following of the defence code. The Institute also helped to develop a new set of reference threats designed to size and verify the suitability of physical protection systems for nuclear installations. Finally, the IRSN was involved in work conducted by the General secretariat for national defence (SGDN) regarding changes in legislation on materials governed by nuclear dissuasion.

Security of radioactive sources

In 2005, the IRSN launched a programme to strengthen security of radioactive sources against malicious acts. The general aim of this programme is to better understand the risks of malicious use of radioactive sources and to draft proposals of technical or statutory measures to reduce these risks.

In 2005, an initial study was conducted to identify the types of sources and situations presenting the greatest risks. The study comprised three main stages:

- inventory of radioactive sources and classification according to different types or families;
- assessment of their sensitivity, i.e. the possible consequences of a malicious act on man or the environment;
- assessment of their vulnerability, i.e. the possibility of success of a malicious act, for the families of radioactive sources with the highest risks.

The work carried out in 2005 mainly concerned sealed radioactive sources.

Studying and developing assessment tools

During 2005, the IRSN continued developing tools to assess the consequences of malicious acts against transport of nuclear materials. These are tools used to assess not only the resistance of packaging to a set of reference threats, but also radioactive discharges which may result from damage caused to containers. In the case of transport of irradiated fuels, it is important to know precisely the behaviour of the material in the event a high-speed projectile reached it. The aim is to specify the characteristics of the fragments produced and the dispersible fraction of these fragments.

Exchange between experts during a meeting within the Division for nuclear defence expertise.

In this context, an international focus group was set up in 2000 including the Gesellschaft für Anlagen und Reaktorsicherheit (GRS) for Germany, the Department of Energy (DOE), the National Regulatory Commission (NRC) and Sandia National Laboratories for the United States, the IRSN for France and the Office for Civil Nuclear Safety (OCNS) for the United Kingdom. The group defined an experimental work programme to study the damage affecting a fuel rod in the event of aggression from a "high-density energy" device, typically, a perforating device. One of the major objectives of the tests is to determine the characteristics of the aerosols produced. Tests are planned in 2007 in Albuquerque (New Mexico), on the site of Sandia National Laboratories.
Prior to this, a significant experimental campaign has started to develop the system and select the irradiated fuel substitute to be used for the experiments. At the same time as its participation in this experimental programme, the IRSN developed several models in 2005 to calculate the damage.

Crisis exercise involving the inventory of nuclear materials.

Today it would appear possible to predict the damage caused to the rods and the quantities of fragments produced using digital simulation. Such models are necessary to be able to extrapolate the results obtained in a specific experimental configuration to a set of cases representative of real transport.

Installation protection exercises

At the request of the HFD, the IRSN organised safety exercises in the field of installation protection with a view to testing decision-making chains and coordination of those involved (operators, public authorities). It also pilots focus groups in charge of preparing the exercises and learning the lessons from them.

Hence in 2005, a national security exercise, the second of its type, took place during the night of 9 to 10 September 2005 at the Cogema La Hague facility (Manche). 150 people took part. The IRSN participated in defining the scenario with the collaboration of Cogema and the national police, and drew up the exercise protocol. Led by the MINEFI (HFD) representative, the exercise was conducted and observed by agents from the Institute. The IRSN has been asked to participate in assessing this exercise.

FOCUS

The convention on physical protection

The review of the agreement on physical protection of nuclear materials and installations significantly extends the scope of the 1979 international agreement and strengthens its effectiveness. This new text owes a lot to France and, in particular, the role played by the director of the Institute who chaired the international group of experts in charge of drawing up the technical and legal changes to the document.
In particular, the Institute was involved in defining the physical protection principles retained in the new agreement, which now covers domestic use of nuclear materials and protection of materials and installations against sabotage. These principles highlight the primary responsibility of the States, who must implement a physical protection system based on the existence of a legal and statutory framework and on the designation of a competent authority. The agreement also introduces a reference to new misdemeanours, in order to ensure better legal protection of materials and installations against the risks of theft and sabotage.
The final act of the review conference was signed on 8 July 2005 at the IAEA headquarters in Vienna. The amendment to the agreement will enter into force when two thirds of the participating States have ratified it.

International activities

In 2005, the IRSN participated, as trainer or speaker, in international courses organised by the IAEA, regarding reference threats (in Serbia) and the principles of physical protection of nuclear materials and installations (in Iran and India). Moreover, in co-operation with the United States Department of Energy (US DOE), the IRSN developed an assessment method and training course on internal threats.

The training was tested in the Czech Republic in 2005. The method was then proposed to the IAEA. It will be used as the basis of a publication in the Agency's "Tecdoc" documents. In 2005, the IRSN also participated in several IAEA focus groups to draw up "Tecdocs" dealing with subjects such as definition of reference threats, identification of vital zones in nuclear installations or transport security.

As regards bilateral relations with the United States, Institute agents were part of the French delegation invited by the US DOE and the US NRC to attend security exercises called "force on force" in an American nuclear power plant.
As regards multilateral relations, the IRSN, involved in the ENSRA, met with its counterparts several times during 2005 for informal exchanges on topical subjects regarding nuclear safety.

[FOCUS]

The nuclear safety culture

Within the spirit of the final act of the agreement on the physical protection of nuclear materials and installations, signed on 8 July 2005, the IRSN has worked on drawing up two doctrine documents stating the basic principles of a nuclear safety culture.

The first text is a document which may be published by the IAEA to meet the demands of the member States. The second, available on the IRSN website under the title *Culture de sécurité dans le domaine nucléaire* is adapted to the French context. This second document specifies the notion of the nuclear safety culture and clarifies the roles and responsibilities of each of the various stakeholders. The goal is to increase awareness, in all actors concerns, of the possible consequences of a lack of attention in terms of safety of nuclear materials and installations.

Glossary

A

ACQUISITION 4
Version 4 of the software used to collect the parameters from a supposedly EDF damaged reactor. ACQUISITION 4 is the first element in the SESAME system, IT tool used by the Technical crisis centre (CTC) to evaluate radioactive releases in the event of an accident affecting an EDF nuclear reactor

AECL
Atomic Energy of Canada Limited - Canadian research organisation

AES 92
3rd-generation reactor developed by Atomstroyexport

AFA 3GLr AA
Advanced Fuel Assembly (2nd generation assembly) - Name given to a certain type of fuel assembly

AFAQ
French Quality Assurance Association

AFNOR
Association Française de NORmalisation - French standardisation association

AFSSET
Agence Française de Sécurité Sanitaire de l'Environnement et du Travail - French agency for environmental and occupational health safety

ALCADE
Name of a fuel management method used in French power plants

Alpha (α symbol)
Radiation composed of helium nuclei, highly ionising but not very penetrating. A sheet of paper is sufficient to stop alpha radiation

ALPHA-RISK
Quantification of cancer and non-cancer risks associated with multiple chronic radiation and exposures: epidemiologicals studies, organ dose calculation and risk assessment - European project to assess chronic risks due to radiation on man

AMANDE
Accélérateur pour la Métrologie et les Applications NEutroniques en Dosimétrie Externe - Accelerator for metrology and neutronics applications for external dosimetry (Cadarache)

ANCLI
Association Nationale des Commissions Locales d'Information - French association of local information commissions

ANDRA
Agence Nationale pour la gestion des Déchets RAdioactifs - National agency for radioactive waste management

ANL
Argone National Laboratory (USA)

ANTARES
Very-high temperature reactor project, graphitemoderated and helium-cooled

AP-1000
3rd-generation reactor developed byWestinghouse (USA)

Aplasia
Arrest or insufficiency in the development of a tissue or organ

APOLLO 2
Neutron calculation code used to calculate the conditions governing the nuclear reaction in a fissile medium

AREVA
Industrial group including the companies Areva T and D, Cogema, Framatome, FBFC, Cogema logistics, Framatome ANP,Technicatome and FCI

ASTEC
Accident Source Term Evaluation Code -Scientific software system used to simulate the train of events in a core meltdown accident in a water reactor, from the initiating event to the release of radioactive products outside the containment. It is developed jointly by the IRSN and GRS

ASTRAL
ASsistance Technique en Radioprotection postAccidenteLle - Calculation code of the IRSN that enables the transfer of radioactive elements into the agricultural sector to be quantified

ATPu
Atelier de Technologie du Plutonium - Plutonium technology workshop (Cogema)

AVN
Association Vinçotte Nucleaire - Vinçotte nuclear association (Belgium)

B

B_4C
Boron carbide used as a neutron absorber in some control rods

BACCARA
Calibration and test bench of devices for the measurement of radon and its decay products (Saclay)

BANCO
BANc d'étude du COlmatage des filtres - Filter clogging test bench (Saclay)

BARC
Bhabha Atomic Research Centre (India)

BARRACUDA
Programme dedicated to the next generation of French nuclear attack submarines

BECARRE
Essais de dégradation de Barres En CArbure de boRe et RElâchements associés - Tests on the degradation of boron carbide control rods and associated releases

Becquerel (Bq)
Official international unit for radioactivity measurement. The becquerel is equal to one disintegration per second

BEMUSE
Best Estimate Methods Uncertainty and Sensitivity Evaluation - OECD programme

Beta (β symbol)
Radiation composed of electrons of negative or positive charge. A few-millimetre air screen or a simple sheet of aluminium can stop this type of radiation

BfS
Bundesamt für Strahlenschutz - German federal office for radiological protection

Biokinetics
Refers to all the accumulation and excretion kinetics of an element in an organism

BLEVE
Boiling Liquid Expanding Vapour Explosion

BNI
Basic Nuclear Installation

BRGM
Bureau de Recherches Géologiques et Minières - Bureau of geological and mining research (France)

BSR
Basic Safety Rule

Burnup fraction
Thermal energy produced by the nuclear fissions in a fuel mass unit. It is measured in megawattsday per ton (MWj/t)

BWR
Boiling Water Reactor

C

CABRI
Test reactor for fuel safety used by the IRSN (CEA)

CABRI-CIP
CABRI International Program - Cabri international programme with a pressurised water loop

Caesium (Cs, atomic number 55)
Noble metal for which biokinetics is very similar to that of potassium released in large amounts during nuclear reactor accidents

Callovo-Oxfordian
Layer of sedimentary rock from the Jurassic period (160 million years) which is the layer studied in the Bure laboratory

CAMARI
Certificat d'Aptitude à Manipuler des Appareils de Radiographie ou de radioscopie Industrielle - Certificate attesting the ability to handle radioscopy and industrial radiography equipment

CANDU
CANada Deuterium Uranium - Canadian design of heavy-water reactor

CaPhé-InE
Caractérisation des Phénomènes de transfert en zone Insaturée d'Éléments traces potentiellement toxiques - Characterisation of transfer phenomena of potentially toxic trace elements into a non-saturated area

CAPITOUL
Canopy and Aerosol Particles Interactions in TOulouse Urban Layer - Measurement campaign to study urban meteorology in Toulouse

CARINEA
Dispositif expérimental pour la CARactérisation pour l'INcendie d'Échantillons Analytiques - Experimental device used to characterise the fire of analytical samples

CATFISH
Caractérisation AnalyTique de la FIltration Sous Humidité - Test bench (Saclay)

CATHARE
Advanced thermal-hydraulic calculation code used to study the behaviour of pressurised water reactors in accident situations.

CCAP
Commission Centrale des Appareils à Pression - Central committee for pressure vessels, consultative organisation in place under the Minister for Industry bringing together representatives from various occupations and experts of techniques used in the construction and monitoring of pressure vessels. Any matter as regards the implementation of laws and regulations concerning pressure vessels, may be forwarded to the CCAP

CDI
Contrat à Durée Indéterminée - Open-ended contract

CEA
Commissariat à l'Énergie Atomique - French Atomic Energy Commission

CEFR
China Experimental Fast Reactor (China)

CERN
Centre Européen pour la Recherche Nucléaire - European organisation for nuclear research (Switzerland)

CFX-5
Three-dimensional fluid mechanics calculation software program

CHIP
Experimental programme on "Iodine chemistry in the primary system" of a pressurised water reactor during a core meltdown accident

CHSCT
Comité d'Hygiène de Sécurité et des Conditions de Travail - Health, safety and working conditions committee

CIREA
Commission Interministérielle des RadioÉléments Artificiels - Interministerial commission for artificial radioelements

CIVA
Software plateform for modelling ultrasonic and eddy current examinsation

CLI
Commission Locale d'Information - Local information commission

CMS
Cote Majorée de Sécurité - Maximum design flood level

CNAM-TS
Caisse Nationale d'Assurance Maladie, Travailleurs Salariés - French employee's national health insurance fund

CNNC
China National Nuclear Corporation (China)

CNPE
Centre Nucléaire de Production d'Électricité - Nuclear power generation site

CNRS
Centre National de la Recherche Scientifique - French national organisation for scientific research

COFRAC
COmité FRançais d'Accréditation - French accreditation committee

COGEMA
COmpagnie GEnérale des MAtières nucléaires - French general company for nuclear materials, member of the Areva group and recently renamed Areva NC

Containment building
Leaktight concrete reactor building housing the reactor pressure vessel, primary system, steam generators and main auxiliaries ensuring the safety of a pressurised water reactor

Corium
Molten nuclear reactor core (fuel and structural materials)

COXST
COmité dédié à l'eXcellence Scientifique et Technique - Committee dedicated to scientific and technical excellence (IRSN)

CPDP
Commission Particulière du Débat Public - Special public debate commission

CPHR
Centro de Protección e Higiene de las Radiaciones - Scientific and technical unit of the Nuclear Energy Agency (Cuba)

CRIS
Centre de Ressources en Information Scientifique - Scientific information resources centre

CRISTAL
French criticality package developed as part of a joint project between the IRSN, CEA and Cogema. It aims at assessing the criticality risk in all nuclear fuel cycle installations and fissile material transport packages.

Criticality (risks)
Risk associated with uncontrolled fission phenomena in fissile materials

Criticality accident
Uncontrolled chain fission reaction triggered in an environment containing fissile materials such as uranium-235 or plutonium-239

CSGD
Commission de Sûreté chargée de la Gestion des Déchets - French waste management safety commission

CSLU
Commission de Sûreté des Laboratoires et Usines - French laboratories and factories safety commission

CST
Commission de Sûreté des Transports - French transport safety commission

CTC
Centre Technique de Crise - Technical crisis centre

CTHEN
Centre Technique d'Homologation des Équipements Nucléaires - Technical centre for nuclear equipment approval

CTHIR
Centre Technique d'Homologation de l'Instrumentation de Radioprotection - Technical centre for the radiological instrumentation approval

D

DAM
Direction des Applications Militaires - Military applications division (CEA)

DATARAD
Database of radioactivity measurements

DDASS
Direction Départementale des Affaires Sanitaires et Sociales - French departmental administration for health and social affairs

DDE
Direction Départementale de l'Équipement - French departmental administration for public engineering

DECOVALEX
DEvelopment of COupled models and their VALidation against EXperiments in the nuclear waste field

DEND
Direction de l'Expertise Nucléaire de Défense - Division for nuclear defence expertise

DGA
Délégation Générale pour l'Armement - French general delegation for armaments

DGSNR
Direction Générale de la Sûreté Nucléaire et de la Radioprotection - General department for nuclear safety and radiological protection

DISCO
German experimental programme on direct heating of the reactor containment when corium is ejected out of the vessel

DISCO
Banc d'essais de DISpersion de COntamination - Contamination dispersion test bench (Saclay)

DISPRO
DISpersion en champ PROche - Near-field dispersion

DIVA
Dispositif pour l'étude de l'Incendie, la Ventilation et l'Aérocontamination - System for the study of fire, ventilation and air contamination (Cadarache)

DOE
Department Of Energy (USA) - Ministry for Energy

Dosimetry
Detection, by assessment or measurement, of the dose of radiation (radioactivity) absorbed by a substance or a person

DPPR
Direction de la Prévention des Pollutions et des Risques - Division for prevention of pollutions and risks (IRSN)

DRACCAR
Deformation and reflooding of a fuel rod assembly during a loss of coolant accident, computation software program used to predict the behaviour of a fuel rod assembly

DRASS
Direction Départementale des Affaires Sanitaires et Sociales - French regional administration for health and social affairs

DRIRE
Direction Régionale de l'Industrie, de la Recherche et de l'Environnement - French regional directorate for industry, research and the environment

DRT
Direction des Relations du Travail - Staff relations department (IRSN)

DSND
Délégué à la Sûreté Nucléaire et à la radioprotection pour les activités et les installations intéressant la Défense - Nuclear safety and radiological protection representative for activities and facilities relating to defence

E

EBMT
European cooperative group for Blood and Marrow Transplantation

EBRD
European Bank for Reconstruction and Development

ECC
European Community Commission

ECCR
European Committe on Radiation Risk (CERI in French)

EDEN
Elementary Dose Evaluation for Natural Environment

EDF
Électricité De France - French national electric utility

EDZ
Excavation Disturbed Zone

EMRAS
Environment Modelling for Radiation Safety - Environmental modelling programme for radiological protection

ENSRA
European Nuclear Security Regulators Association

ENVIRHOM
Research programme aimed at studying the radionuclide accumulation processes and the biological effects, during this accumulation, induced in the living organisms of plants, animals and humans subjected to chronic exposure

EOT
Échelon Opérationnel des Transports - Operational transport section (IRSN)

EPIC
Experimental Platform In Chernobyl

EPICE
Évaluation des Pathologies Induites par les contaminations chroniques en CÉsium - Assessment of the pathologies induced by chronic contamination by caesium

EPICUR
Cobalt-60 irradiator used to study the behaviour of iodine under radiation (Cadarache)

EPR
European Pressurised water Reactor

EPR
Electronic Paramagnetic Resonance

ERICA
Environmental Risk from Ionising Contaminants: Assessment and management

ERMSAR
European Review Meeting on Severe Accident Research

EURANOS
European approach to nuclear and radiological emergency management

EURATOM
EURopean ATOMic energy community

EURODIF
EUROpean uranium enrichment by gaseous DIFfusion plant (Pierrelatte)

EUROFAB
FABrication en EUROpe, project which is part of the programme for disposal of Russian and American military plutonium exceeding defence requirements

EURSAFE
European project of the 5th FPRD on research priorities in the field of severe accidents

EXTREME
Research programme aimed at studying the consequences of extreme climatic events on the transfers of radioactivity between the compartments of the environment

F

FASSET
Framework for ASSessment of Environmental impacT

FBFC
Société Franco-Belge de Fabrication de Combustibles - Franco-Belgian fuel manufacturer

FGI
Franco-German Initiative for Chernobyl

FIRST
Further Improvement of Radiotherapy of cancer through side effect reduction by innovative application of adult Stem cells transplantation for prevention and Treatment of deterministic radiation effects - Research programme of the 6th FPRD

FLAMME_S
Software that simulates in a simple manner the evolution of carbonated product fires in installations comprising mechanically ventilated, confined premises

FLAMME_S/SIMEVENT
FLAMME_S software combined with SIMEVENT software that simulates a fire in a group of premises connected by a ventilation system and doors

Foundation raft
Reactor foundations in a nuclear power plant

FPRD
Framework Programme for Research and Development (European Union)

FPRTD
Framework Programme for Research and Technological Development (European Union)

FPT-3
PHEBUS FP test dedicated to studying the effects of B_4C on the degradation of a reactor core and on the release of fission products

FRED
Fasset Radiation Effects Database - Database created during the European FASSET programme (5th FPRD)

Fuel assembly
Cluster of fuel rods, connected with a metallic structure, used in nuclear reactors

FUTURAE
A Future for Radioecology in Europe

FzK
Forschungszentrum Karlsruhe - German research centre

G

Gamma (γ symbol)
Highly penetrating but not very ionising electromagnetic radiation, emitted during the disintegration of radionuclides. Shielding of concrete or lead is necessary to protect persons

GAMA
OECD focus group on severe accidents in nuclear reactors

GATeL
Génération Automatique de Tests à partir d'une description Lustre - Automatic generation of tests from a Lustre description

GDP
Gaseous Diffusion Plants (Areva NC)

GOR
General Operating Rules

GP
Standing advisory group

GPD
Standing advisory group of experts for waste

GPR
Standing advisory group of experts for nuclear reactors

GPU
Standing advisory group of experts for plants

GRNC
Groupe Radioécologie Nord-Cotentin - Nord-Cotentin Radioecology Group (France)

GRS
Gesellschaft für Anlagen- und Reaktorsicherheit (Germany) - German IRSN counterpart

GWj/t
Fuel burnup rate. Giga Watt Days per tonne of fuel, customary unit for measuring fuel assembly irradiation, expressed as the energy extracted from the assembly in the reactor per tonne of initial uranium

H

Hatch
Device for large equipment access in the reactor building

HDR
Eligibility to supervise research

Hematopoietic cells
Cells from which the various blood cells are formed (red cells, white cells, platelets)

HFD
Haut Fonctionnaire de Défense du ministère de l'Économie, des Finances et de l'Industrie - French High Civil Defence Servant of the Ministry for Economy, Finance and Industry

HLLL
High-Level and Long-Lived

HRD
Human Resources Division

HTR/VHTR
High Temperature Reactor/Very High Temperature Reactor

I

IAEA
International Atomic Energy Agency

ICARE
Interprétation des Cœurs Accidentés pour les

Réacteurs à Eau, code de calcul simulant la dégradation d'un cœur de réacteur à eau durant un accident grave - Interpretation of damaged cores for water reactors, computer code simulating the degradation of a water reactor core during a severe accident

ICARE-CATHARE
Scientific computation software that accurately describes the reactor core degradation up until tank rupture during a core meltdown accident

ICPE
Installation Classée pour la Protection de l'Environnement - Classified installation for the protection of the environment

ICRP
International Commission on Radiological Protection

ICSBEP
International Criticality Safety Benchmark Evaluation Project

ICST
Ingénierie de la Connaissance Scientifique et Technique - Scientific and technical knowledge engineering

IEC
International Electrotechnical Commission

IGR
Gustave Roussy Institute (France)

IGS
Institute of Geological Sciences (Ukraine)

INBS
Secret basic nuclear installation

INERIS
Institut National de l'Environnement industriel et des RISques - French national institute for the industrial environment and hazards

INEX 3
INternational EXercise (3rd of this type) - International emergency exercise in case of nuclear accident

INPI
Institut National de la Propriété Industrielle - French national institute of industrial property

INRETS
Institut National de REcherche sur les Transports et leur Sécurité - French national institute for transport and safety research

INRS
Institut National de Recherche et de Sécurité - French national research and safety institute

InVS
Institut de veille sanitaire - French national institute of public health surveillance

IPPE
Institute of Physics and Power Engineering (Russia)

IPSN
Institut de Protection et de Sûreté Nucléaire - Institute for nuclear safety and protection

IRIS TÜM
Irradiation device for fuel plates of research reactors

IRMA
IRradiation MAterial - Cobalt-60 irradiation cell, test facility intended to study the response to dose and/or dose rate exposure (Saclay)

IRS
Incident Reporting System. This is the only international report system at the disposal of safety authorities and government organisations. It provides an evaluation of the most important events for safety occuring in nuclear plants, as well as detailed information on the analyses of primary causes and the lessons learnt in terms of safety. The IRS is managed by a joint secretariat formed by the NEA and IAEA

IRSN
Institut de Radioprotection et de Sûreté Nucléaire - French institute for radiological protection and nuclear safety

ISIS
Calculation software that precisely simulates the progress of a fire, gas, smoke and structures in confined spaces with mechanical ventilation

ISO
International Standard Organisation

ISO 9001
European standard for quality-based management systems

Isotopes
Elements whose atoms have the same number of electrons and protons, but a different number of neutrons: they have the same name and the same chemical properties. Around 325 natural isotopes and 1,200 artificially-created isotopes are currently listed

ISTC
International Science and Technology Center - Russian institute conducting civilian research programmes in laboratories previously engaged in military activities

IUR
International Union of Radioecology

J

JAEA
Japan Atomic Energy Agency

K

KAERI
Korea Atomic Energy Research Institute

KINS
Korea Institute of Nuclear Safety

KROTOS
Facility intended to study the corium-water interaction, and more specifically the vapour explosion resulting from a rapid energy transfer from corium to water (CEA)

kV
kiloVolt

L

L3-COM-MAPPS
Industrialist (Canada)

LECI
Laboratoire d'Examen de Combustibles Irradiés - Laboratory for Study of Irradiated Components (CEA)

LMDN
Laboratoire de Métrologie et de Dosimétrie des Neutrons - Laboratory of metroloy and neutron dosimetry (Cadarache)

LOCA
Loss Of Coolant Accident of a PWR

LOLF
Institutional act on the finance law

LPG
Liquified Petroleum Gas

M

M5
Type of pressurised water fuel cladding

Masurca
Breeder model - Research reactor (CEA)

MC3D
Multi Composants 3 Dimensions - Software program which calculates the corium-water interaction or vapour explosion

MEDD
Ministère de l'Écologie et du Développement Durable - French Ministry for Ecology and Sustainable Development

MEDEC
French health exhibition

MELODIE
Modèle d'Evaluation à LOng terme des Déchets Irradiants Enterrés - Model for the long-term assessment of buried radioactive waste

Mesenchymal
Relating to embryonic connective tissue

mGy
Milligray - Unit of absorbed radiation dose of the international system of units

MICADO
Model uncertainty for the mechanism of dissolution of spent fuel in nuclear waste repository - European project of the 6th FPRD on the influence of uncertainties regarding the release of spent fuel radionuclides on the overall safety of a geological disposal

MIMAUSA
Mémoire et Impact des Mines Anciennes d'Uranium : Synthèse et Archivage - Memory and impact of uranium mines: summary and archives

MINEFI
Ministère de l'Économie, des Finances et de l'Industrie - French Ministry for Economy, Finance and Industry

MLLL
Medium-Level and Long-Lived

MONTE CARLO
Design method based on random draws

MORET
Monte Carlo code for simulation of neutron transport (multi-group approximation) to calculate the effective multiplication factor (keff) of three-dimensional complex systems.

MOX
Fuel of uranium (natural or depleted) and plutonium oxides

MOZART
Analytic tests to study the oxidation kinetics of clads under air

MSC
Mesenchymal Stem Cells

mSv
Millisievert - Unit derived from dose equivalent of the international system of units

MWe
MegaWatt electric

N

N4
N4 series, series of 1,450 MWe pressurised water reactors operated by EDF

NAGRA
Nationale Genossenschaft für die Lagerung radioaktiver Abfälle (Switzerland) - National cooperative for radioactive waste storage, organisation in charge of the radioactive waste disposal

NEA
Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD)

NF-PRO
Near Field PROcesses

NNSA
National Nuclear Safety Administration (China)

NRC
Nuclear Regulatory Commission (USA)

NSRR
Nuclear Safety Research Reactor (Japan)

Nuclear fuel
Fissile material (capable of undergoing fission reactions) used in a reactor to develop a nuclear chain reaction. After being used in a nuclear reactor, this is referred to as irradiated fuel

Nuclear island
Assembly comprising the nuclear boiler, the installations relating to the fuel and the equipment needed to operate and ensure the security of this assembly

Nuclear materials
Materials which could be used to manufacture a nuclear explosive device. They are defined according to their fissile (for a fission device), fusible (for a thermonuclear bomb), or fertile (capacity to produce fissile or fusible materials) characteristics. French legislation covers six nuclear materials: plutonium, uranium, thorium, tritium, deuterium and lithium 6 (deuterium and lithium 6 are not radioactive)

Nuclear safety
Set of measures taken at all levels of design, construction, operation and decommissioning of the nuclear installations to prevent accidents and limit their effects

Nureth
Congress attended by specialists in nuclear reactor thermal-hydraulics

O

OCNS
Office for Civil Nuclear Security

OECD
Organisation for Economic Co-operation and Development (European Union)

OECD/NEA:
OECD Nuclear Energy Agency

OJ
Official Journal

OPCW
Organisation for the Prohibition of Chemical Weapons

OPERA
Observatoire PErmanent de la RAdioactivité dans l'environnement - Permanent Environmental Radioactivity Observatory

OPRI
Office de Protection contre les Rayonnements Ionisants - French Office for Protection against Ionising Radiation

OSIRIS
Experimental reactor (CEA)

P

P'4
Plant series comprising twelve more recent 1,300 MWe water-pressurised reactors

P4
Plant series comprising eight 1,300 MWe water-pressurised reactors at Paluel, Flamanville and Saint-Alban

PACA
Provence-Alpes-Côte-d'Azur region (France)

PAMINA
Performance Assessment Methodologies IN Application to guide the development of the safety case - European project of the 6th FPRD on the contribution of modelling carried out as part of the performance assessments of geological disposals, to draw up the safety dossier

PASEPRI
Plan d'Actions pour la Surveillance de l'Exposition des Patients aux Rayonnements Ionisants - Action

plans for the monitoring of patient exposure to ionising radiation

PCO
Poste de Commandement Opérationnel - Operational control centre

PHARE
Poland-Hungary Assistance for Reconstruction of the Economy

PHEBUS-FP
Experimental programme on the degradation of a nuclear reactor core and the release of fission products (FP)

PHEBUS FPT3
Test of the PHEBUS FP programme

PHENIX
250 MWe fast neutron reactor (CEA)

PIC
Programme d'Intérêt Commun - Common interest programme

PICSEL
Propagation de l'Incendie de Combustibles Solides dans un Environnement Laboratoires et usines - Propagation of solid fuel fire in a laboratory and plant environment (IRSN/Areva programme)

Plutonium (Pu, atomic number 94)
Transuranic chemical element. The isotope 239 has a half life of 24,110 years

POLLUTEC
International trade fair for environment-related equipment, technologies and services for industry

Primary system
Reactor coolant system operating in a closed loop, comprising a series of components that ensures the circulation of water used to extract the heat given off by the reactor core

PRISME
PRopagation d'un Incendie pour les Scénarios Multi-locaux Élémentaires - Propagation of a fire for elementary, multi-premises scenarios (OECD programme)

PROTECT
Protection of the environment from ionising radiation in a regulatory context

PSA
Probabilistic Safety Assessment

PSA1
Level 1 probabilistic safety assessment quantifying the risks of core meltdown

PSA2
Level 1 probabilistic safety assessment quantifying the probabilities of fission product releases in case of severe accident

PUI
Plan d'Urgence Interne - Internal emergency plan

PWR
Pressurised Water Reactor

R

R&D
Research and Development

Radioactivity
Property of certain chemical elements whose nuclei spontaneously disintegrate into other elements emitting ionising radiation

Radioelement
Natural or artificial radioactive element

Radiological protection
Set of measures intended to ensure protection of the population and workers against ionising radiation sources

Radionuclide
Radioactive isotope of an element

RAPHAEL
ReActor for Process heat, Hydrogen And ELectricity generation

REBUS
REactivity tests for a direct evaluation of the BUrnup credit on Selected irradiated LWR fuel bundles

RECI
RECombiner of Iodine - experimental system used to assess the influence of recombiners on the chemistry of iodine in the containment (Saclay)

REP-Na
Experimental programme in the sodium loop of the CABRI reactor aimed at studying the behaviour of fuel during a power transient

RHF
Laüe Langevin Institute's high-flux reactor (Grenoble)

RIA
Reactivity Insertion Accident

ROSATOM
Russian federal agency for atomic energy

S

SAPIDE/LUDD
Documentary database collecting the incidents and events related to nuclear installations other than reactors (laboratories and plants)

SARNET
Severe Accident Research NETwork of excellence - European network of excellence on core meltdown accidents in water reactors (6th FPRTD)

SATURNE
Experimental installation with an extractor hood aimed at studying the progress of a fire (Cadarache)

SCANAIR
Software used to calculate an RIA-type transient

SCPRI
Service Central de Protection contre les Rayonnements Ionisants - French central service for protection against ionising radiation

SDIS
Service Départemental d'Incendie et de Secours - French departmental fire and rescue service

SENSIB
SENSIBilité radioécologique, projet de recherche - Radioecological sensitivity, research project

SERENA
Steam Explosion REsolution for Nuclear Applications (OECD programme)

SESAME
Schéma d'Évolution des Situations Accidentelles et Méthodes d'Évaluation - Accident progression analysis and assessment methods

SEVESO
Accident happened in Italy in 1976 which gave its name to a European directive on industrial accident risks

SGDN
Secrétariat Général de la Défense Nationale - French General Secretariat for National Defence

SIEVERT
Information and assessment system of the exposure to cosmic radiation during flights

SIGIS
Système d'Information et de Gestion de l'Inventaire national des Sources de rayonnements ionisants - Information and management system for the national inventory of ionising radiation sources

SIMEVENT
Software simulating aeraulics in a ventilation system developed as part of a joint project between the IRSN, SGN and Cogema

SIPA
Pressurised water reactor accident simulator developed and used by the IRSN

SISERI
Système d'Information de la Surveillance de l'Exposition aux Rayonnements Ionisants - Ionising radiation exposure monitoring information system

Site effect
Modification of the characteristics of seismic movements resulting from the mechanical properties of soils or topography. It may increase the devastating effect of an earthquake

SNA
Nuclear attack submarine

SNG
New generation submarine

SNLE
Nuclear-powered ballistic missile submarine

SNM
Military nuclear system

SPN
Permanent nuclear section of the Central committee for pressure vessels

SSI
StatensSträlskyddsinstitut (Sweden) - Radiological protection authority

SSTC
State Scientific and Technical Center on nuclear and radiation safety (Ukraine)

STARMANIA
Station for the study of airborne contamination transfer and mechanical strength under incident and accident conditions (Saclay)

STEME
Environmental Sample Processing and Metrology Department

STI
Scientific and Technical Information

STUK
Stäteilyturvakeskus (Finland) - Safety authority

SYLVIA
Software system of the IRSN used to study ventilation, fire and air contamination

SYMBIOSE
Systemic approach for modelling the fate of chemicals in biosphere and ecosystems

T

TACIS
Technical Assistance for Commonwealth of Independent States

TID
Total Indicative Dose

TONUS
Code developed by the CEA on behalf of the IRSN using models that govern the distribution of hydrogen in the containment

TOSQAN
TonuS Qualification ANalytique - Experimental containment used to reproduce a small-scale accident scenario enacting a hydrogen risk in a nuclear reactor containment (Saclay)

TROI
Test for Real cOrium Interaction - Experimental Installation designed to study the corium-water interaction (Korea)

U

UF_6
Uranium hexafluoride

UIAR
Ukrainian Institute of Agricultural Radioecology (Ukraine)

UNSCEAR
United Nations Scientific Committee on the Effects of Atomic Radiations

UO_2
Uranium oxides

UP1
Biggest plant for the reprocessing of spent nuclear fuels with a view to them being recycled in France (Areva NC)

UP2-400
Irradiated nuclear fuel reprocessing plant, definitely shutdown, located at the La Hague site (Areva NC)

UP2-800
Irradiated nuclear fuel reprocessing plant, located at the La Hague site (Areva NC)

UP3-A
Irradiated nuclear fuel reprocessing plant, located at the La Hague site (Areva NC)

UPRES
Unité Propre de Recherche de l'Enseignement Supérieur - Specific research unit for higher education

USDOE
US Department Of Energy (USA) - Ministry for Energy of the United States

USNRC
US Nuclear Regulatory Commission (USA)

V

VD3 900
Third 10-yearly outage programmes of 900 MWe reactors

VDEW
Verbandes der Elektrizitätswirtschaft (Germany) - Electricity group

VHE
Very High Efficiency

VHTR
Very High Temperature Reactor

Voxel
Elementary volume in a digital, three-dimensional framework

VVER or WWER
Vodo Vodiannoï Energititschesky Reactor or Water Water Energetic Reactor - Russian-designed reactors, whose operating principle is similar to that of western pressurised water reactors

W

WHO
World Health Organization

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1 Current events, strategy and organisation

2 Management and support

3 IRSN activities

IRSN

INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Finance Ledger of the Annual Report 2005

Didier DEMEILLERS,
Director in charge of Financial Affairs

Contents

Management report

1. OVERALL OUTLOOK

The year 2005 has seen the implementation of a revised tax system, excluding from liability to VAT the grant for the operation of the Institute provided by the State via the Ministry for Ecology and Sustainable Development (MEDD). This modification of the tax system, extended to the grant provided by the Ministry of Defence has, for the first time in 2005, enabled the presentation of a balanced statement of receipt and expenditure forecasts (EPRD). The budget deficit, recurring since the creation of the IRSN, has disappeared. However, this balance will automatically disappear as from 2006, because of the implementation of payroll tax. It will be definitively restored if the fiscal legislation department (DLF) confirms the alignment of the business and corporation taxes with the limitation of the principle of profitability, which governs the new VAT system for the Institute. Furthermore, amending decision no.1-2005 (DM1-2005), presented to the Board of Directors in June 2005, incorporated the carrying forward of investments not terminated in the 2004 financial year, i.e. €2.2 million, paid into working capital at closure 2004. Almost all these operations were balanced in the financial year.

The implementation of the 2005 budget had as its main objective the effective recovery of balances, in conformity with the EPRD, and the resumption of investment, whose level had been significantly reduced during previous financial years, while essentially achieving the scientific and technical goals pursued. A number of new urgent matters having appeared with regard to investment during this financial year. It was considered preferable to redeploy, in favour of these programmes, the resources allocated to operational activities, rather than revising the investment plan initially envisaged. The most significant of these operations relates to the modernization of the IRSN offer as regards dosimetry (dosage measurement) in respect of the workers, the replacement of silver film by digital technology being imposed *de facto* in the short term by the market. A transfer of €10 million of appropriations (that is, 3% of the IRSN's budget) between operational activities and investment has been effected in order to undertake these operations, within the framework of the budgetary interchangeability from which the Institute benefits. In accordance with the directives in the matter, this amendment did not require the approval of the Board of Directors, inasmuch as it did not affect the overall balance of the budget nor impair the result. These operations, launched in the second half of 2005, are not completed at the end of the financial year, thus involving a carry-over of appropriations of €12.2 million in working capital, for re-application in 2006.

Budgetary balance

F/year (in € million)	2003	2004	2005	Variation 2005/2004
Total resources	242.9	247.2	287.7	+16.4%
Total expenditures	246.1	258.0	268.2	+4.0%
Balance	-3.2	-10.8	19.5	NB

The 2005 operation shows a budgetary balance prospectively overvalued by the carrying forward of investments of €12.2 million.

Over 2005, the modification of the tax system (pro-rata VAT system) generated additional receipts of €33 million and additional expenditure of approximately €23 million, corresponding to the VAT which has become irrecoverable. The difference, approximately €10 million, has enabled absorption of the budget deficit resulting from the underestimation of the tax provision allowed for on creation of the IRSN in 2002.

All in all, the financial year 2005 is therefore marked by:

- the observance of the EPRD 2005 balances approved by the Board of Directors;
- a rate of budget realization of 95.7% (against 97.5% in 2004), a variation of €13 million with the EPRD, corresponding to €12.2 million through irregular realization of certain investments.

2. INCOME STATEMENT ANALYSIS

2.1. Income

F/year (in € million)	2003	2004	2005	Variation 2005/2004
Turnover	36.6	35.2	36.1	+2.6%
Grants	198.1	206.7	240.2	+16.2%
Other operating income	1.8	3.7	2.2	-40.5%
Financial income	1.0	1.4	1.2	-14.3%
Extraordinary income	25.2	6.7	4.2	-37.3%
Total	262.7	253.7	283.9	+11.9%

2.1.1.

Increased by €32.9 million in comparison with 2004 (+13.4%), operating income amounts to €278.5 million, including:

- €236.8 million for the grant from MEDD, an increase of €34.9 million, because of non-subjection to VAT, due to modification of the tax system.
- €2.9 million under the agreement with the Ministry of Defence, being a slight increase (€0.2 million) due to modification of the VAT system, adjusted to that applicable to the grant from MEDD.
- €0.5 million in respect of other grants, in particular from local authorities, as against €2 million in the previous year.
- €36.1 million of own resources (as against €35.2 million in 2004) from the expert activity of the IRSN, other service provision or co-financing of research programmes. These resources are fairly stable in comparison with the preceding financial year, the increase of 2.6% enabling compensation for inflation. This stability masks a loss of market share in dosimetric activity, compensated overall by the increase in turnover in other fields.
- €2.2 million of sundry income as against €3.8 million for the preceding year. This income includes royalties related to industrial property (€0.1 million, stable), sundry current management income (€0.4 million, stable), write-backs on depreciation and provisions (€0.5 million, increasing) and finally €1.2 million of cancellation of accruals in respect of previous financial years, as against €3.3 million in 2004.

2.1.2.

Financial income, amounting to €1.2 million, is lower than in the preceding year (- €0.2 million, i.e.-14%) by reason of a more even spread of the Institute's operating expenditure throughout the financial year, in particular with its principal supplier, the CEA (expenses of centres, scientific subcontracting, BNI, etc.).

2.1.3.

Extraordinary income is lower at €4.2 million. It essentially consists of the share of investment grants inherited from the CEA, a share transferred to the income statement (€3.8 million). These accounting operations, not affecting the balance of the budget, will continue to decrease gradually until they disappear completely.

Total income for the 2005 financial year amounts to €283.9 million as against €253.8 million in 2004 and €261.7 million in 2003.

2.2. Expenditure

F/year (in € million)	2003	2004	2005	Variation 2005/2004
Purchases	124.9	118.0	128.7	+9.1%
Personnel	103.3	107.7	109.2	+1.4%
Taxes and dues	1.4	1,3	1.2	-7.7%
Depreciation	25.0	13.6	13.4	-1.5%
Provisions	3.4	4.2	8.3	+97.6%
Other	3.0	1.2	2.1	-75.0%
S/T Operation	**261.0**	**246.0**	**262.9**	**+6.9%**
Financial expenditure	NB	NB	0.1	NB
Extraordinary expenditure	0.3	13.8	0.4	NB
Total	261.3	259.8	263.4	+1.4%

2.2.1.

Operating expenditure for 2005, amounting to €262.9 million, is appreciably higher (by €16.9 million, i.e. +6.9%) in comparison with 2004. This increase is due to the modification of the Institute's tax system, with the arrival of an irrecoverable VAT charge, representing 85% of the VAT paid to suppliers. The operating expenditure breaks down as follows:

- Total personnel charges, including the employees provided by the CEA (+€3.5 million, as compared with the accounts closed by the accountant) and tax on remuneration (+€2.1 million): €109.2 million in 2005, as against €107.7 million in 2004 and a forecast in the DM1-2005 of €110 million. This reduction of €0.8 million is explained by variations occurring in the realization of the Institute's recruitment plans.
- Taxes and dues: €1.2 million (i.e. €3.3 million - €2.1 million, reprocessed above in personnel charges) as against €1.3 million in 2004. This posting is broadly less than the forecast in DM1-2005, by an amount of €5.4 million, but a provision for contingencies and charges is allowed for in the sum of €4.7 million, in respect of the taxes for 2005, unknown on closure of the accounts. This provision is constituted in particular for business tax, the assessment of which is effected according to the recommendation of the DLF, by way of precaution, by limiting added value in respect of the business as a whole.
- Depreciation in the sum of €13.4 million, stable in relation to the previous year (€13.6 million), but in slight decline in comparison with the DM1-2005 (€14 million). Allocation to provisions is €8.3million, including €4.7 million for taxation (see above) and €3.6 million for commitments in respect of early retirement (Capron agreement).
- Purchases of goods and services of €128.7 million, as against €118 million in 2004.

This increase in fact masks a reduction in volume of about €8 million, compensated by the tax impact assessed at €19 million (16.6%, i.e. 85% of 19.6%) in respect of irrecoverable VAT. Other charges of €2.1 million, as against €1.2 million in 2004. They represent cancellations of receipts issued in previous financial years for €0.5 million and royalties paid for use of patents and software of €1.4 million.

F/year (in € million)	2003	2004	2005	Variation 2005/2004
60 - Purchases	43.3	58.3	69.1	+18.5%
61 - External services	63.6	42.3	41.1	-2.8%
62 - Other external services	18.0	17.4	18.4	+5.7%
Total	124.9	118.0	128.6	+9.1%

The reading of this table shows:

- the stability of item 60 - purchases, the variation of 18.5% resulting from the combined impact of irrecoverable VAT (16.6%) and inflation (1.9%);
- a drop in item 61 - external services, resulting in particular from the reduction in subcontracting at the heart of the business, attributable to the increase in capacity of the Institute's workforce;
- a relative drop, taking into account the irrecoverable VAT effect, in item 62 - other external services, a reduction attributable to better control by the Institute of its activities and costs.

2.2.2.

Financial expenditure of €0.1 million comes primarily from the interest on the loan contracted for the financing of the purchase of the UIS building at Fontenay-aux-Roses. The charge corresponding to the flat-rate annual tax (corporation tax scheme) is cited by way of reminder.

The extraordinary expenditure of €0.4 million as against €13.8 million in 2004 will henceforth be insignificant. The total of expenditure for the financial year is €263.4 million, as against €259.8 million in 2004 and €261.3 million in 2003.

3. RESULT AND FINANCING

F/year (in € million)	2003	2004	2005	Variation 2005/2004
Result	0.4	-6.0	20.4	NB
SFC	10.3	5.1	37.8	+641.2%
Variation of working capital	-3.2	-10.8	19.5	NB

3.1.

The financial year shows a profit of €20.4 million as against a loss of €6 million in 2004 and a profit of €0.4 million in 2003.

Moreover, the amending decision of the EPRD forecast a profit of €8.5 million for 2005. The variation of €11.9 million (i.e. €20.4 million - €8.5 million) in comparison with the DM1-2005 is explained by:

a reduction in operating expenditure in consequence of the need for redeploying the Institute's budgets in order to effect certain investments, for an overall total of €10 million, not provided for in the DM1-2005;

- an increase of €0.1 million in the financial income of the Institute;
- extraordinary income of €0.3 million;
- cancellation of accruals, issued in previous financial years, of €1.2 million;
- reduction of depreciation expenditure of €0.6 million;
- on the other hand, a reduction in the share of investment grant transferred to the income statement, which reduces this profit by €0.3 million.

3.2.

The Institute's self-financing capacity (SFC), initially fixed at €17.6 million in the EPRD, is automatically adjusted to a higher level, due to the improvement in the result of €11.9 million and also increased by €8.3 million, due to reincorporation of the allocation to provisions (taxation and pensions), provided for in the EPRD in the form of charges and not provisions.

The IRSN's self-financing capacity is therefore increased to €37.8 million to ensure the financing of its investments. Total projects launched in 2005 or deferred from 2004 amount to €38.6 million, the execution of which has been effected up to €26.4 million, which results in the carrying forward to 2006 of a total amount of €12.2 million, the balance of these operating commitments. Significant in amount, this carrying forward is explained both by the delay involved in certain operations and the launching during the year of certain projects not initially provided for. This €12.2 million, included in working capital in respect of 2005, shall be the subject of a withdrawal from working capital in respect of 2006, in accordance with the instructions from the Budget department (circular 4BCJS-05-3152 of 1 August 2005).

4. BALANCE SHEET ANALYSIS

4.1. Liabilities

F/year (in € million)	2003	2004	2005	Variation 2005/2004
Net assets	40.6	34.6	55.0	+58.9%
Investment grants	18.9	12.3	8.5	-30.9%
S/T Shareholders' equity	59.5	46.9	63.5	+35.4%
Provisions	8.4	12.4	20.3	+63.7%
S/T Invested capital	67.9	59.3	83.8	+41.3%
Financial debts	0.1	-	7.3	NB
Advances & deposits	2.4	2.4	2.5	+4.2%
Supplier debts	84.4	40.6	40.7	+0.2%
Tax and social debts	11.4	16.7	20.5	+22.8%
Other debts	41.8	2.9	1.7	-41.4%
Short- and medium-term S/T debts	140.1	62.6	72.7	+16.1%
Total	208.0	121.9	156.5	+28.4%

4.1.1.

Taking account of a profit of €20.4 million, long-term capital comprises:

- net assets of €55 million;
- €8.5 million of investment grants;
- €20.3 million of provisions;

i.e. a total of €83.8 million, as against €59.3 million in 2004 and €67.9 million in 2003.

4.1.2.

Short- and medium-term debts amount to €72.7 million, as against €62.6 million for the previous year. This increase is explained primarily by the taking out of a loan for €7.2 million, intended to finance the purchase of a building, and by the adjustment (in the sum of €3.6 million) of the social liabilities in respect of holiday pay. These short- and medium-term debts break down as follows:

- €7.3 million of financial debts;
- €2.4 million of advances on pending orders;
- €40.8 million of supplier debts;
- €20.5 million of tax or social liabilities;
- €1.7 million of sundry debts.

4.2. Assets

F/year (in € million)	2003	2004	2005	Variation 2005/2004
Capital assets	47.9	50.1	62.5	+24.8%
Advances & deposits	7.8	9.8	0.1	-99.0%
Operating receivables	108.3	48.5	26.7	-44.9%
Treasury	44.1	13.5	67.2	+397.8%
Total	208.1	121.9	156.5	+28.4%

4.2.1.

Capital assets have appreciably increased (by 24.8%) with a net value of €62.5 million, as against €50.1 million the previous year. After several financial years where this item remained stable and represented the ageing of the IRSN installations, the tendency is reversed and should continue in 2006.

4.2.2.

Current assets have increased to €94.1 million, as against €71.8 million in 2004. They breaks down into:

- €26.7 million of operating receivables;
- €67.2 million of treasury.

The strong growth in treasury noted at the close of the financial year 2005 corresponds to:

- the delay (see above) in the investment plan (€12.2 million);
- the provisions allowed for in the financial year (€8.3 million);
- the strong reduction in operating receivables (- €21.6 million).

The financial year 2005 finishes with working capital increasing by €19.5 million, within which €12.2 million of investments carried forward will be taken up in amending decision no. 1 of the 2006 financial year.

CONCLUSION

The 2005 budget was carried out in accordance with the budgetary commitments undertaken by the Board of Directors.

The accounts do not take into consideration the future expenditure on dismantling, the procedures in respect of which were not completely clarified at 31 December 2005.
This provisioning, estimated at €31 million, has been incorporated in amending decision no. 1 of 2006, thanks to the direct allocation to the IRSN of a portion of the income from the tax on the BNIs in respect of 2006. The IRSN has requested the perpetuation of this measure as from 2007, to enable it in particular to cope with this future expenditure.
The disappearance of the Institute's budget deficit, in consequence of the revision of its tax system, enables it to present a healthier financial situation in respect of its current operations.
With the effective subjection of the IRSN to the payroll tax as from 2006, this improvement may only be maintained, insofar as the tax system adopted for VAT is extended to corporation tax and business tax.

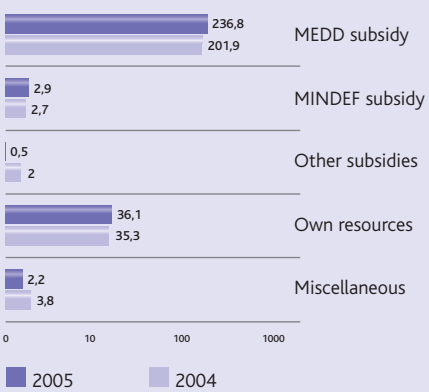
Profit & Loss account

INCOME

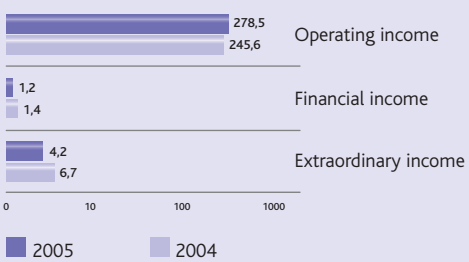
In euros excluding tax	2005	2004	2003
Operating income	**278,533,129.53**	**245,598,908.63**	**235,482,280.96**
Net total turnover	36,082,032.27	35,164,526.17	35,590,211.96
Operating subsidies [1]	240,153,038.38	206,681,399.76	198,098,871.94
Write-backs on depreciation and provisions	522,051.53	80,417.64	20,504.32
Transfers of charges	54,410.88	36,839.37	25,349.47
Other income	1,721,596.47	3,635,725.69	1,747,343.27
Financial income	**1,190,690.45**	**1,446,579.93**	**1,018,763.58**
From holdings	104,780.21		
Other interest and equivalent income	19,690.46	8,710.77	
Positive exchange differences	4,800.05	19,953.00	38,568.13
Net income on sale of negotiable investment securities	1,061,419.73	1,417,916.16	980,195.45
Extraordinary income	**4,146,552.62**	**6,721,564.71**	**25,211,622.50**
Income from asset transfers	20,516.72		
Investment subsidies transferred to the year's Profit & Loss Account	3,791,414.60	6,554,482.13	18,742,326.22
Non-staggered investment grants	265,856.15		
Management operations	68,765.15	167,082.58	6,469,296.28
TOTAL INCOME	283,870,372.60	253,767,053.27	261,712,667.04
Debit balance = loss		**6,045,350.60**	
OVERALL TOTAL	283,870,372.60	259,812,403.87	261,712,667.04

(1) As from 1 January 2005, the operating grants paid by the Ministry for Ecology and Sustainable Development (MEDD) and the Ministry of Defence (MINDEF) are exempt from VAT.

Operating income (in € million)



Detailed income (in € million)



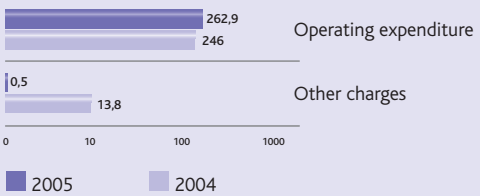
EXPENDITURE

In euros excluding tax	2005	2004	2003
Operating expenditure	**262,953,012.10**	**245,997,066.23**	**261,015,076.71**
Third-party consumption for financial year (1)	132,158,168.96	158,454,902.47	182,831,266.23
Tax, rates and equivalent payments	3,302,586.05	2,776,145.74	1,381,124.89
Personnel charges (2)	103,617,061.44	65,805,418.98	45,440,248.53
Depreciation and provision allowances	21,734,857.59	17,771,491.98	28,404,363.46
Other charges	2,140,338.06	1,189,107.06	2,958,073.60
Financial expenditure	**99,153.11**	**33,456.39**	**21,155.29**
Depreciation and provision allowances			
Interest and equivalent charges	88,837.44	9,805.48	1,881.88
Negative exchange differences	10,315.67	13,650.91	19,199.31
Net charges on sale of negotiable investment securities		10,000.00	74.10
Extraordinary expenditure	**375,520.45**	**13,763,131.25**	**260,535.00**
Management operations	292,742.13	13,763,131.25	35.00
Capital operations	82,778.32		500.00
Depreciation and provision allowances			260,000.00
Tax on profit	**18,750.00**	**18,750.00**	
Fixed annual taxation	18,750.00	18,750.00	
TOTAL EXPENDITURES	263,446,435.66	259,812,403.87	261,296,767.00
Credit balance = profit	**20,423,936.94**		**415,900.04**
OVERALL TOTAL	283,870,372.60	259,812,403.87	261,712,667.04

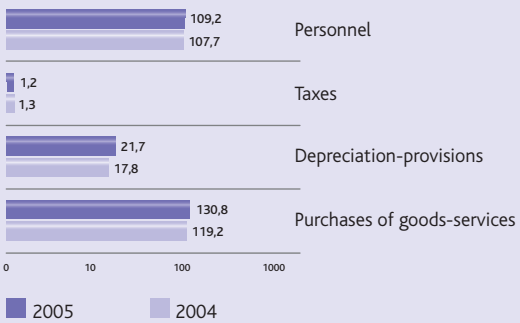
(1) Since 1 January 2005, VAT on purchases has become irrecoverable in proportion to the activity not subject to VAT.

(2) The personnel charges increase with the arrival of the CEA employees opting for the IRSN. This increase is compensated for by a decrease in third-party consumption.

Detailed expenditure (in € million)



Operating expenditure (in € million)

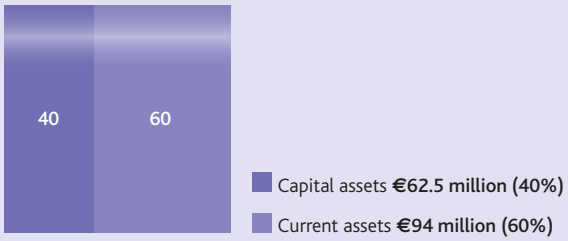


Balance sheet

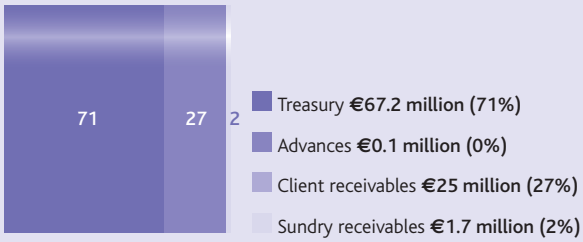
ASSETS

In euros			2005	2004	2003
	Gross	Depreciation and provisions	Net	Net	Net
Intangible fixed assets	8,368,894.53	6,771,569.16	1,597,325.37	1,742,147.10	1,845,335.08
Tangible fixed assets	104,762,296.29	45,204,104.93	59,558,191.36	47,190,404.05	45,435,018.48
Financial fixed assets	1,314,180.01		1,314,180.01	1,196,078.27	635,212.81
Fixed assets	**114,445,370.83**	**51,975,674.09**	**62,469,696.74**	**50,128,629.42**	**47,915,566.37**
Stocks and work-in-progress					34,943.08
Advances and deposits paid on orders	140,499.71		140,499.71	9,824,069.06	7,758,726.96
Operational receivables					
Client receivables	*25,116,260.99*	*131,679.02*	*24,984,581.97*	*29,826,904.94*	*28,178,006.45*
Other receivables	*1,731,507.74*		*1,731,507.74*	*18,533,312.85*	*79,899,947.86*
	26,847,768.73	131,679.02	26,716,089.71	48,360,217.79	108,077,954.31
Sundry receivables				1,069.28	1,069.28
Negotiable investment securities	65,313,646.29		65,313,646.29	10,938,217.44	33,680,806.20
Liquid assets	1,905,219.84		1,905,219.84	2,565,411.71	10,370,525.94
Prepayments				72,469.00	241,517.33
Current assets	**94,207,134.57**	**131,679.02**	**94,075,455.55**	**71,761,454.28**	**160,165,543.10**
OVERALL TOTAL	208,652,505.40	52,107,353.11	156,545,152.29	121,890,083.70	208,081,109.47

Detailed assets



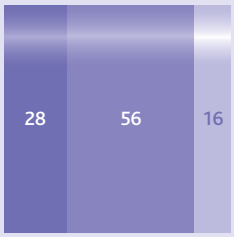
Current assets



LIABILITIES

In euros	2005	2004	2003
Allocation	8,782,859.59	8,782,859.59	8,782,859.59
Reserves	31,844,160.61	31,844,160.61	31,428,260.57
Carried forward	-6,045,350.60		
Financial year result (profit or loss)	20,423,936.94	-6,045,350.60	415,900.04
Net assets	**55,005,606.54**	**34,581,669.60**	**40,627,020.20**
Investment subsidies	8,505,605.26	12,297,019.86	18,851,501.99
Shareholders' equity	**63,511,211.80**	**46,878,689.46**	**59,478,522.19**
Risk provision	1,278,000.00	1,260,000.00	260,000.00
Taxation provision	9,250,369.57	1,300,000.00	
Provision for charges	9,806,000.00	9,882,369.57	8,150,000.00
Contingent liability provision	**20,334,369.57**	**12,442,369.57**	**8,410,000.00**
Loans & debts from credit houses	7,283,771.11		136,224.68
Sundry financial loans & debts	190.50	312.42	312.42
Advances and deposits received on current orders	2,468,724.45	2,426,504.71	2,426,504.71
Supplier debts and connected accounts	31,459,617.08	33,998,794.86	79,002,887.85
Tax and social debts	20,529,969.47	16,649,279.72	11,409,966.28
Other operational debts			39,514,301.48
Debts on fixed assets and related accounts	9,306,807.42	6,583,920.72	5,386,816.45
Other debts	1,650,490.89	2,792,448.24	2,197,809.41
Prepayments and accrued income		117,764.00	117,764.00
Debts	**72,699,570.92**	**62,569,024.67**	**140,192,587.28**
OVERALL TOTAL	156,545,152.29	121,890,083.70	208,081,109.47

Debt analysis



Tax and fiscal debts **€20.5 million (28%)**
Supplier debts **€40.7 million (56%)**
Other debts **€11.5 million (16%)**

Intermediate management balances

HEADINGS	31/12/05	%	31/12/04	31/12/03
Turnover	36 082 032.27	13.06%	35,164,526.17	35,590,211.96
+ Operating subsidies	240,153,038.38	86.94%	206,681,399.76	198,098,871.94
FINANCIAL YEAR PRODUCTION	**276,235,070.65**	**100%**	**241,845,925.93**	**233,689,083.90**
- Third-party consumption	132,158,168.96	47.84%	158,454,902.47	182,831,266.23
ADDED VALUE	**144,076,901.69**	**52.16%**	**83,391,023.46**	**50,857,817.67**
- Taxes and rates	3,302,586.05	1.20%	2,776,145.74	1,381,124.89
- Personnel charges	103,617,061.44	37.51%	65,805,418.98	45,440,248.53
GROSS OPERATING SURPLUS	**37,157,254.20**	**13.45%**	**14,809,458.74**	**4,036,444.25**
+ Write backs, transfers of charges	576,462.41	0.21%	117,257.01	45,853.79
+ Other income	1,721,596.47	0.62%	3,635,725.69	1,747,343.27
- Depreciation and provision allowances	21,734,857.59	7.87%	17,771,491.98	28,404,363.46
+ Write back on equipment subsidies	4,057,270.75	1.47%	6,554,482.13	18,742,326.22
- Other charges	2,140,338.06	0.77%	1,189,107.06	2,958,073.60
OPERATING RESULT	**19,637,388.18**	**7.11%**	**6,156,324.53**	**-6,790,469.53**
+ Investment income	1,190,690.45	0.43%	1,446,579.93	1,018,763.58
- Financial charges	99,153.11	0.04%	33,456.39	21,155.29
CURRENT PRE-TAX RESULT	**20,728,925.52**	**7.50%**	**7,569,448.07**	**-5,792,861.24**
+ Extraordinary income	89,281.87	0.03%	167,082.58	6,469,296.28
- Extraordinary expenditure	375,520.45	0.14%	13,763,131.25	260,535.00
EXTRAORDINARY RESULT	**-286,238.58**	**-0.10%**	**-13,596,048.67**	**6,208,761.28**
- Tax on profit	18,750.00	0.01%	18,750.00	
FINANCIAL YEAR RESULT	20,423,936.94	7.39%	-6,045,350.60	415,900.04

Forecast and completion reconciliation

PROFIT & LOSS ACCOUNT in euros	2005 budget	2005 actual
INCOME		
Sale of services	37,865,760.00	36,082,032.27
Public subsidies	239,703,400.00	240,153,038.38
Other operating income	1,154,780.00	3,301,319.10
Internal transactions	4,893,000.00	4,333,982.85
TOTAL INCOME	283,616,940.00	283,870,372.60
CHARGES		
Personnel charges	110,073,780.00	103,617,061.44
Other operating costs	151,060,960.00	138,089,268.20
Internal transactions	14,000,000.00	21,740,106.02
TOTAL CHARGES	275,134,740.00	263,446,435.66
RESULT (PROFIT)	**8,482,200.00**	**20,423,936.94**
RESULT (LOSS)		
TOTAL PROFIT & LOSS ACCOUNT BALANCE	283,616,940.00	283,870,372.60

TRANSFER OF RESULT TO SFC TABLE in euros	2005 budget	2005 actual
RESULT	**8,482,200.00**	**20,423,936.94**
+ Accounting value of asset items sold		5,248.43
+ Allowances for depreciation and provisions	14,000,000.00	21,734,857.59
- Income from asset transfers		20,516.72
- Share of investment subsidies transferred to profit & loss account		3,791,414.60
- Write-back on depreciation and provisions	4,893,000.00	522,051.53
SELF-FINANCING CAPACITY (SFC)	17,589,200.00	37,830,060.11

SUMMARY FINANCING TABLE in euros	2005 budget	2005 actual
SELF-FINANCING CAPACITY	**17,589,200.00**	**37,830,060.11**
Acquisitions of tangible and intangible assets	27,028,360.00	25,560,548.88
Financial fixed assets	780,000.00	876,486.61
Financial debt repayment		121.92
TOTAL APPROPRIATIONS	27,808,360.00	26,437,157.41
Public investment subsidies		
Other resources (excluding internal transactions)	8,009,160.00	8,062,672.70
TOTAL RESOURCES	8,009,160.00	8,062,672.70
CONTRIBUTIONS TO WORKING CAPITAL	**-2,210,000.00**	**19,455,575.40**

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