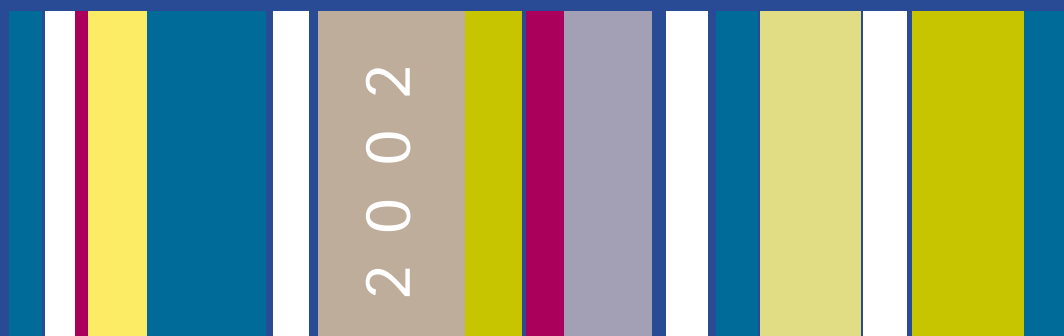
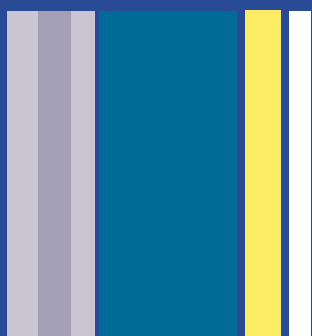


IRSN ACTIVITY REPORT




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Glossary



Editorial



Jacques Repussard
Director General



Jean-François Lacronique
President of the Board of Directors

The year 2002 will remain an outstanding year for nuclear safety and radiation protection. In fact, it saw the achievement of a long "imminent" reform in the area of risk management, with the creation of a new entity on the one hand, the Nuclear Safety and Radioprotection Institute (IRSN) for public research and expertise, and the overhaul of the structures in the public authorities on the other hand through the creation of the General Directorate for Nuclear Safety and Radiation Protection (DGSNR) and the Nuclear Safety Directorate for Defence (DSND). The major complementary disciplines that are radiation protection, safety and security, have been joined together today in France, as has as the clear separation of the roles between authorities, experts and operators.

Beyond combining the resources and personnel from IPSN (Institute for Protection and Nuclear Safety) and part of OPRI (Office for Protection against Ionising Radiation), into the same public establishment, this reform implies several major challenges for the new Institute.

The very wide spectrum of the Institute's responsibilities, materialized through its five ministerial guardianships, shall require careful management of the resources dedicated to expertise carried out to support public authorities. The contract of agreed objectives, which will be submitted in 2004, shall consolidate this system, bringing a mediumterm viewpoint.

Furthermore, the independence in judgement which IRSN – public reference expert in its area of competence – must demonstrate, will be ensured in the long term only if the Institute, through its research efforts, and with the support of the network of co-operation with its peers on the international level, shows its excellence scientifically as well as the relevance of its technical positions.

From this viewpoint, reinforcement of the relations is necessary between expertise and research within the Institute, and the development of scientific partnerships with French operators involved in nuclear technologies, the national research organisations (CEA, CNRS, INSERM, IFREMER...), the institutions ensuring missions in other risk areas (INERIS, InVS, AFSSA, AFSSE, INRS...), and the foreign Institutes (GRS in Germany, NRPB in the United Kingdom, NRC in the USA...).

Lastly, the confidence granted by our fellow citizens for the national system implemented to manage risks related to radiation implies continuous efforts to inform, openness towards the population and training development, a responsibility which IRSN shall fully assume.

In the autumn of 2003, mostly due to preparatory work conducted until the spring by Daniel Quéniart, to whom we pay homage, a new organisation of the Institute will be implemented, with the mission to face up to all those challenges.

The nuclear safety and security issues, the requirements for health, safety and protection of the environment within the framework of the national strategy of sustainable development, create an obligation of success. Thanks to the significant and internationally recognized amount of scientific knowledge, expertise, scientific and technical tools, of which this first annual report provides a short overview, we can certainly achieve this success.

Jacques Repussard
Director General

Jean-François Lacronique
President of the Board of Directors

Presentation of IRSN

> Preventing nuclear and radiobiological risks

The Nuclear Safety and Radioprotection Institute is a public scientific and technical expert organisation, specialising in the assessment of risks due to ionising radiation, particularly in nuclear facilities and during transport of nuclear materials.

Both main missions of IRSN are complementary: research enhances knowledge and expertise provides technical advice; research represents the basis of a quality assessment of the most complex issues.

More specifically, the main areas of activity of the Institute cover the safety of nuclear facilities and transport of nuclear and fissile matter, the protection of human health and the environment against ionising radiation, protection and control of nuclear matter, protection against malevolent actions and crisis management.

IRSN maintains partnerships with nearly 30 countries and takes part in large-scale research programmes. It takes part in the development of international scientific and technical consensus and in the development of international recommendations.

IRSN is a public establishment of an industrial and commercial nature created by the law of May 9th, 2001. Its missions and operations are defined in a decree of February 22nd, 2002.

The creation of IRSN is part of the reform regarding the control of nuclear safety and radiation protection in France, which follows the general pattern of the creation of health security agencies and clarifies the roles of the different actors by separating the implementation and the promotion of nuclear power programmes, control authority functions and technical assessment functions.

Technical assessment functions are entrusted to IRSN, control authority functions for facilities and civil transport being ensured by the General Management of the nuclear safety and radiation protection under the auspices of the Ministries of Industry, Environment and Health. IRSN is in charge of technical activities previously carried out by IPSN (Institute for Nuclear Protection and Safety) and OPRI (Office for Protection against Ionising Radiation). It is placed under the joint guardianship of the Ministries of Environment, Industry, Research, Health and Defence.

With a budget of about 250 million Euros, IRSN employs 1,500 experts and researchers, covering various disciplines from life sciences to physics of nuclear reactors.

In 2002, IRSN had a provisional organisation, with the members of the Board of Directors being appointed at the beginning of 2003, as were the President of the Board and the Director General.



2002: results of the first year of IRSN



Daniel Quéniart
Director Advisor

From the end of February 2002 to the appointment of the Director General in March 2003, I ensured the functions of the IRSN provisional administrator, born of the meeting of the technical teams of IPSN — now separated from CEA — and OPRI.

During this transition period, it was essential to carry on ensuring correctly all the research and expertise technical missions, previously conducted by IPSN and OPRI, and especially the technical support of the various administrations concerned. The 2002 activity report seems to testify that a good technical vitality brought by the new Institute, is maintained.

Building its operation by joining teams from two organisations with different modes of thought and management, thus ensuring for the former OPRI and the former permanent secretary of the Inter-ministerial commission for artificial radio-elements (CIREA), a clear separation between expertise functions and authority functions (now assumed by the DGSNR), managing relations with CEA with a very large part of the personnel made available by the CEA and which can adopt for three years their maintenance in the CEA staff, represented new and formidable challenges, even if the long lead time of IRSN had allowed deep-rooted preparatory work conducted by the IPSN and OPRI directors.

After one year of existence, IRSN has a large part of the units and texts required for its operation:

- The members of the Board of Directors, except for personnel representatives, have been appointed, by decree dated January 3rd, 2003; the Chairman of the Board was appointed by decree dated January 21st, 2003;
- Upon the suggestion of the latter, the Director General was appointed by decree dated March 17th, 2003;
- The work committee held its first meeting on February 25th, 2003 and the negotiations concerning the company agreement have progressed (agreement signed by the Director General and four labour organisations on May 26th, 2003);
- With the exception of the convention related to the use by IRSN of the CABRI and PHEBUS reactors, whose implementation was difficult and which was signed on June 20th, 2003, the texts governing the daily relations between CEA and IRSN regarding safety, personnel, premises and technical support were, with a single exception, signed between September 2002 and February 2003; the convention regarding the transfer of means, rights and obligations has not been yet finalised, but is now well in progress.
- A decision from the Prime Minister's office established at 58 the number of ex-OPRI and ex-permanent secretary of CIREA positions deployed to authority missions previously exercised by these units; for obvious reasons concerning personnel management, this decision can only be implemented gradually, as the effective personnel movements depend on voluntary agreements;
- The income tax system of IRSN was set by the fiscal legislation branch in August 2002 and January 2003.

However, the scientific committee remains to be created and the orientation committee related to defence-related activities has not yet met.

Above all, the pooling of cultures and the synergy of the teams remain to be improved. First steps were made in this direction. Common values — competence, independence, transparency, responsiveness, creativity — were defined and an organisation draft for the new Institute was underway. Nevertheless, the implementation of the organisation had to be deferred in the absence of a Board of Directors; the related work have since resumed by the new management team to give IRSN and its personnel renewed confidence after years of uncertainty.

Daniel Quéniart
Director Advisor

Board of Directors of IRSN

Chairman

Jean-François LACRONIQUE
President of the Board of Directors

State representatives

Emmanuel DUVAL
Armament inspection manager, representing the Minister of Defence

Marie-Claude DUPUIS
Director of the industrial environment department, Department for the Prevention of Pollution and Hazards, representing the Minister of the Environnement

Thierry MICHELON
Deputy Director of environment risk management, General Directorate for Health (DGS), representing the Minister for Health

Stéphane GRIT
Branch manager of nuclear industry, General Directorate for Energy and Raw Materials (DGMF), representing the Minister for Industry

Bernard FROIS
Director of the "Power, transport, environment, natural resources department", Technology Department, representing the Minister for Research

Philippe SIMÉON-DREVON
Manager of the national mission supporting nuclear risk management, representing the Minister for Civil Security

Jean-Denis COMBEXELLE
Director of the Labour Relations, representing the Minister for Employment

Nicolas VANNIEUWENHUYZE
Office manager, Budget Department, representing the Minister for the Budget

André-Claude LACOSTE
Director of Nuclear Safety and Radiation Protection

René PELLAT
Delegate for nuclear safety and radiation protection for activities and installations concerned by national defence provision

Qualified personalities

Jean RANNOU
Air Force general

Jacques VERNIER
Douai Mayor

Maurice LAURENT
Former Department Manager of the National Assembly

Dominique GOUTTE
Director of the major heavy ion accelerator

Claude BIRRAUX
Member of Parliament

Personnel Representatives

The election of the personnel representatives will be held on September 9th, 2003.

Government commissioner

Philippe VESSERON
Director for the Prevention of Pollution and Hazards

State controller

Daniel RACINET



The first board of directors of the IRSN met on May 19th, 2003.



Organisation chart on July 10th, 2003

IRSN management

Director General: **Jacques REPUSSARD** ● General Deputy Director: **Michel BRIÈRE** ● Director Advisor: **Daniel QUÉNIART** ● Assistant Director for Protection: **Annie SUGIER** ● Assistant Director for Waste Safety: **Michèle VIALA** ● Assistant Director to the Director in Charge of Programmes: **Catherine LECOMTE** ● Assistant Director to the Director in Charge of International Relations: **Jean-Bernard CHÉRIÉ** ● Secretary General: **Jean-Baptiste PINTON** ● Deputy Director in Charge of Human Resources and Administrative Affairs: **Louis CROUX** ● Assistant Director for Communication: **Marie-Pierre BIGOT** ● Head of Quality, Safety, Security and Environment Division: **Alain BARDOT** ● Advisor for Radiation Protection: **Philippe HUBERT** ● Official representative for crisis organisation: **Bruno DUFER** ● Internal auditor: **Jean-Claude SAEY**.

Director of Vésinet site: **Philippe JAMET** ● Deputy Director: **Jean-Luc PASQUIER** ● Director of the Safety Assessment Department: **Jean-Christophe NIEL** ● Director of the Department for the Prevention and Study of Accidents: **Michel POURPRIX, interim** ● Director of the Department for Human Health Protection and Dosimetry: **Patrick GOURMELON** ● Director of the Department for the Protection of the Environment: **Jean-Claude BARESCUT** ● Director of the Security Research Department: **Joseph LEWI** ● Director of the Department for the Security of Radioactive Materials: **Denis FLORY**.

Delegate Treasurer

Jean-Claude DALE

IRSN

Protecting human beings and environment



The most recent OPERA¹ station was implemented in Arles in March 2002.

32,000

For the monitoring of workers handling radio-elements or exposed to such radio-elements, IRSN performed 32,000 radio-toxicological analyses on biological samples in 2002.

260,000

The SISERI database implemented by IRSN lists 260,000 workers exposed to ionising radiation.

1.9 million

1.9 million of dosimeters operated by IRSN in 2002.

Contributing to the protection of the environment and human health, being able to answer precisely the authorities and public inquiries on the impacts of ionising radiation sources on the environment and health, are the main objectives of IRSN. To meet efficiently those objectives, the Institute performs measurements and conducts studies and also develops research programmes to improve the state of knowledge.

The areas covered are very wide. Concerning the environment, the objective is to measure and study the consequences of human activities on natural environments: measurement and observation networks, radio-ecology works in terrestrial and marine environments, study on radionuclide bio-accumulation in the environment, research on "natural" radioactivity...

Concerning human health, radiation protection involves populations in general, but also workers and patients more specifically exposed to ionising radiation. The objective is to assess the exposure of different populations in various conditions, as for example, by chronic incorporation of radionuclides and the resulting risks, but also to deepen the knowledge of the physical and biological effects induced by irradiation in order to develop appropriate therapeutic responses. In case of accident or incident, the Institute uses its competencies to assess it and makes suggestions regarding the measures to be taken in order to minimize its consequences. A crisis centre is permanently on duty to respond to such situations.

> Networks for detecting and measuring radioactivity in the environment

IRSN ensures nationwide permanent monitoring of ambient radioactivity levels in various environments (air, water, soil, food...) which people may be in contact with. Merging IPSN (Institute for Protection and Nuclear Safety) and OPRI (Ionising Radiation Protection Agency) into a single organisation allows IRSN to have a complete and consistent set of measurement networks. Those networks cover alerts (detection of an incident or an accident, location of anomalies), the monitoring of industrial installations and the understanding of transfers to the environment (phenomena modelling). This monitoring contributes to the appraisal of the doses received by populations and to the assessment of the impact of human, industrial or medical activities on the environment.

Today, IRSN is based on three complementary networks:

- Fully automated alert stations (Téléray, Hydrotéléray, Téléhydro and Sara) providing a real-time alert in case of abnormal increase of radioactivity or ambient radiation;
- 300 sampling stations, located in the environment, generally near nuclear sites and around former mining or industrial sites. This network measures natural and artificial radioactivity in the air, atmospheric dust, water and soils. Foodstuffs and drinking water are monitored as well as are fauna and flora. The network contributes to check that operators observe their requirements regarding radioactive effluent releases;
- Observatories: This network, which includes 34 stations, is called OPERA¹; it is used to measure radioactivity, up to the level of traces, in samples collected in the environment. The purpose is to understand the processes controlling distribution, in time and space, of the radionuclides of natural and artificial origin coming from various environments, including the food chain. The knowledge of radioactivity levels is necessary for modelling the transfer processes of radionuclides in the environment. This network is also used to develop measurement databases essential for the scientific studies on the variability of the observed radioactivity levels.

Today, all networks cover the entire territory of France. Every year, more than 36,000 samples are taken from the various compartments of the environment, including agricultural foodstuffs. They are subject to more than 100,000 laboratory analyses, focusing on the different alpha, beta and gamma emitters. Moreover, there are thousands of results permanently produced by continuous measurement systems (alert stations) of radioactivity in the air, atmospheric aerosols and water from the main rivers.

ALERT STATIONS

Téléray: National network measuring continuously monitors ambient gamma radiation. In 2002, a new radiation probe was installed in the Château de Vincennes, in the Paris region, bringing the number of stations to 180. Technical improvements in electronics (modem, transmission speed...) will allow to a complete modernisation of the network as of 2003. A direct link was installed at the beginning of 2002 between technical the crisis centre of IRSN in Fontenay-aux-Roses (Hauts-de-Seine) and the control centre for intervention resources located in Le Vésinet (Yvelines).

Téléhydro: Network continuously monitoring the radioactivity of wastewater in big cities. The installation in 2002 of 4 new radiation probes in Lyon (Rhône), Rouen (Seine-Maritime), Strasbourg (Bas-Rhin) and Nantes (Loire-Atlantique) brings the number of operational stations to 8. Moreover, an autonomous and remote access mobile device, used for punctual measurements, was produced and has been available since the end of 2002.

Hydrotéléray: Network continuously measuring radioactivity of water from big rivers. This network now comprises 6 stations, including the Agen (Lot-et-Garonne) radiation probe installed on the Garonne river under the Layrac bridge.

Sara: Network measuring the alpha, beta and gamma activities of aerosols. In 2002, 5 new radiation probes were installed in Biarritz (Pyrénées-Atlantiques), Montélimar (Drôme), Strasbourg (Bas-Rhin), Lille (Nord) and Brest (Finistère), bringing the number of equipment implemented in the airport meteorological stations to 11.

1. OPERA : Observatoire PErmanent de la RAdioactivité.

> Consequences of the Chernobyl accident fallout in France

The Chernobyl (Ukraine) accident fallout is still subject to studies and working groups on the assessment of the catastrophe's impact on the environment and health, and on the lessons to be drawn for crisis management. The Institute has, for a long time, implemented an organisation, reinforced since the creation of IRSN, intended to bring technical support to the authorities in case of nuclear accident.

Research to reinforce expertise

To improve its expertise capacities in the radioecological area, IRSN develops scientific programmes. The purpose of the CAROL (CAmargue Rhône Languedoc) programme was thus to determine the origin of the radionuclides present in measurable quantities in the lower Rhône valley and to foresee their medium and long-term development. This project covered all environments: atmospheric, terrestrial, aquatic, continental and marine, and was used to respond to many inquiries. As an example, the study of the origin of the ^{137}Cs present in soil was used to quantify the relation between the deposits resulting from the Chernobyl accident and the rains of the first week in May 1986, period during which contaminated air masses passed over France; it led to modelling a map of ^{137}Cs deposits in France due to the accident. This map can be superimposed to the map displaying the fallout of the atmospheric tests of nuclear weapons, reproduced from measures performed by OPRI since 1961. It is therefore possible to provide data on the level and origin of the current ^{137}Cs activities in French soil.

Another application of IRSN research involves the study of the Chernobyl accident fallout in Corsica. Upon the request of the public authorities, three sampling and measurement campaigns were performed in Corsica by OPRI and IPSN in 2001. Their purpose was to check the assessments of deposits, reproduce as far as possible food chain contamination in 1986 using the measurements performed at this time, and determine current food contamination levels. The thyroid doses likely to have been received by children having lived in the most contaminated areas were assessed. The study was the subject of publications and a public introduction in Ajaccio (Corsica) in January 2002.

Lastly, within the framework of a "workshop area" of about 1,000 m² located in the Mercantour region (South-East mountain range), a study focused on the origin and localisation of radioactivity concentration points in high altitudes and on food chain contamination

which may result from this. This study, performed in collaboration with French and international universities, was used in particular to produce predictive mapping, on catchments area scale, of the surfaces likely to show radioactivity concentration points.

STUDY GROUPS

To improve answering questions regularly asked by the media and the public about the Chernobyl accident, IRSN implemented a study group including personalities from various areas: members of local information commissions (CLI), journalists, academics, experts from the Institute. Reflection focuses for example on the quality and relevancy of the measurements performed in 1986, the mapping of soil contamination, the consistency of dose calculations, the effects of thyroid contamination, etc. The work of this group led IRSN, for its part, to produce the modelling of a complete mapping of French soil contamination by ^{137}Cs . This map will be submitted to the European Commission, to replace the map currently displayed in the publications of this Commission ("European atlas"). Besides, in August 2002, the Minister of Ecology and Sustainable Development and the Minister of Health entrusted Professor Aurengo with the task to set a mapping of French territorial contamination following the Chernobyl accident, in order to assess the risks of population contamination and the doses received. IRSN is actively engaged in this work. It provided the results of the measurements it performed from 1980 to 1999 as well as all the reports published by IPSN (Institut for Protection and Nuclear Safety) since 1986 concerning the accident.



Soil sampling in Corsica to measure the quantity of Cesium-137 currently present.

> A new organisation for IRSN crisis management

In case of a nuclear or radiological accident, IRSN deploys an organisation and resources to advise public authorities. It is in particular able to rapidly provide information to nuclear safety authorities (DGSNR, DSND) including technical information about the nature and severity of an accidental situation affecting a nuclear facility as well as its possible development and the consequences which might result for the population and the environment. In addition, it suggests appropriate protective actions to be implemented in the field. In case of effective release of radioelements, the Institute collects and processes all measurement results of performed to distinguish the contaminated area and suggests appropriate measures to restore the environment.

An appropriate organisation for the situation

To respond efficiently to its missions, the Institute has an organisation enabling it to provide a diagnosis of the situation and a forecast on its development:

- An on-call team, comprising 14 agents, able to react in less than one hour on a 24/7 basis;
- A technical crisis centre (CTC) in Fontenay-aux-Roses (Hauts-de-Seine), available on a 24/7 basis. In case of crisis, it can gather a team of 20 to 25 persons, equipped with specific means: telecommunications, documentation, computer systems and databases, including mappings. This team transmits technical advice and information to public authorities in order to ensure the protection of the population;
- A mobile unit responsible for locally coordinating measurements, transmitting these to the CTC for all the necessary technical elements needed to carry out its

250

IRSN experts are available to be mobilised at the technical crisis centre.

expertise and performances and, if necessary, health control of the populations. It has mobile measuring equipment, emergency vehicles and specialised vehicles that can be used depending on the severity of the event (seven lorries, two trailer trucks and one rail vehicle). This

is deployed by the control centre of the intervention resources in Le Vésinet (Yvelines), in permanent contact with the CTC.

Merging IPSN and OPRI technical activities allows IRSN to now dispose of a wide range of technical resources. In 2002, coordination of those various means was implemented, allowing their complementarities to be used to improve the Institute's expertise in case of crisis: joining on-call teams, centralising information towards the CTC of Fontenay-aux-Roses (Hauts-de-Seine), implementing the mobile unit... This synergy results in more direct and rapid exchange between the CTC expert team and the mobile unit in the field. Twelve crisis exercises were performed in 2002: eight concerned EDF installations, one concerned the La Hague (Cotentin) plant, one concerned Laue-Langevin (Grenoble in Isère) institute, one concerned CEA installations in Cadarache (Bouches-du-Rhône) and one concerned a transport of nuclear materials. In addition to IRSN staff, each of those exercises mobilizes public authorities as well as operators locally and nationally. Those exercises are used in particular to assess the exchange between the various actors. Furthermore, computer tools developed by IRSN to assess the possible development of an accident and the possible consequences on the environment and on the populations of a release of radioactive materials are tested under these circumstances.

A CD-ROM ON NUCLEAR RISK FOR LOCAL DECISION-MAKERS

Faced with the difficulties encountered by local actors to represent clearly what a nuclear accident would entail, in 2000 the Institute created a CD-ROM entitled "Information on nuclear risk and its management". After the preparation of the necessary technical information, the definition of specifications and design, animated sequences were defined in 2001 with the assistance of a multimedia company. In 2002, a call for tender enabled the selection of the company to produce the CD-ROM. Its distribution was scheduled for June 2003.



The crisis technical centre in operation.

> IRSN involvement in environment radiation protection

With the increase in environmental concerns, an international consensus was established on the need to implement, beyond the protection of human beings, a system intended to protect the environment against the ionising radiation effects. The assessment of the risk associated with the presence of radionuclides in the environment implies the development of new research orientations in radioecology (study of the chronic accumulation of low-dose radionuclides, consideration of the multipollution phenomena (metals and radionuclides)... Within this framework, IRSN launched two new research programmes to acquire knowledge and develop indispensable tools for the implementation of a method to assess radioecological risks.

The ENVIRHOM programme

Started in 2001, the purpose of the ENVIRHOM programme is to assess the effects of chronic exposures to very low levels by associating experts specialising in the protection of human beings and the environment. The attempt is to study radionuclide accumulation phenomena in ecosystems and people in a multipollution environment. The knowledge bases obtained will significantly contribute to the implementation of a system intended to protect the environment.

Another purpose of the ENVIRHOM programme is to assess the radionuclide transport from radioactivity tank compartments that are water, soil and sediments, towards the living environment. Furthermore, within ecosystems, the wide diversity of those transports is associated to the complexity of the chemical and biological recycling mechanisms of the radionuclides and to the food patterns of the organisms present in those environments. The programme in particular studies the biological changes produced in the long term. ENVIRHOM will be used to develop dose-effect relations between concentrations of chemical species present in the environment and the ecological consequences affecting individuals and the population (chemical and radiological toxicities).

The first experiences focussed on uranium and highlighted and quantified uranium bioaccumulation processes as well as the mechanisms implemented according to the environment and uranium chemical forms, for phytoplankton and invertebrates.

Other studies highlighted bioaccumulation processes and capacities of transfer to consumers. Lastly, some biological effects (death rate, impact on growth...) could be associated with the exposure modalities and therefore were used to draw dose-effect relation curves.

The SYMBIOSE programme: towards an integrated assessment-support platform

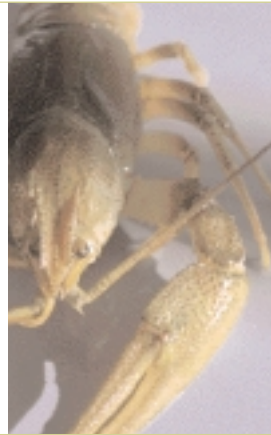
Started in 2002, the purpose of the SYMBIOSE programme is to develop a set of coordinated computer tools intended to support the assessment and management of the risk of radioactive contamination in the environment. The objective is to process the impact on both human beings and the environment from the scale of an individual to the scale of a whole population.

Depending on the situations studied, the programme can use more or less complex and detailed models. Thus, in preliminary forecast studies, some phenomena can be treated using simplified descriptions whereas the interpretation of delicate real cases may require more sophisticated models. The aim of the approach used is to process a wide range of situations. It should allow the dynamic modelling of radionuclide transport within and between the different environments forming the continental biosphere on time scales ranging from one day to several dozens of years. This approach will be applied to the waste storage, basic nuclear installations (BNI) in normal or accidental operations.

The work in 2002 focussed on restructuring existing models and integrating them into a modular set used to assess the dosimetric impact on human beings, linked to an ingestion of contaminated food from a simplified continental biosphere.



The uranium bioaccumulation is studied in bivalves and crayfish.



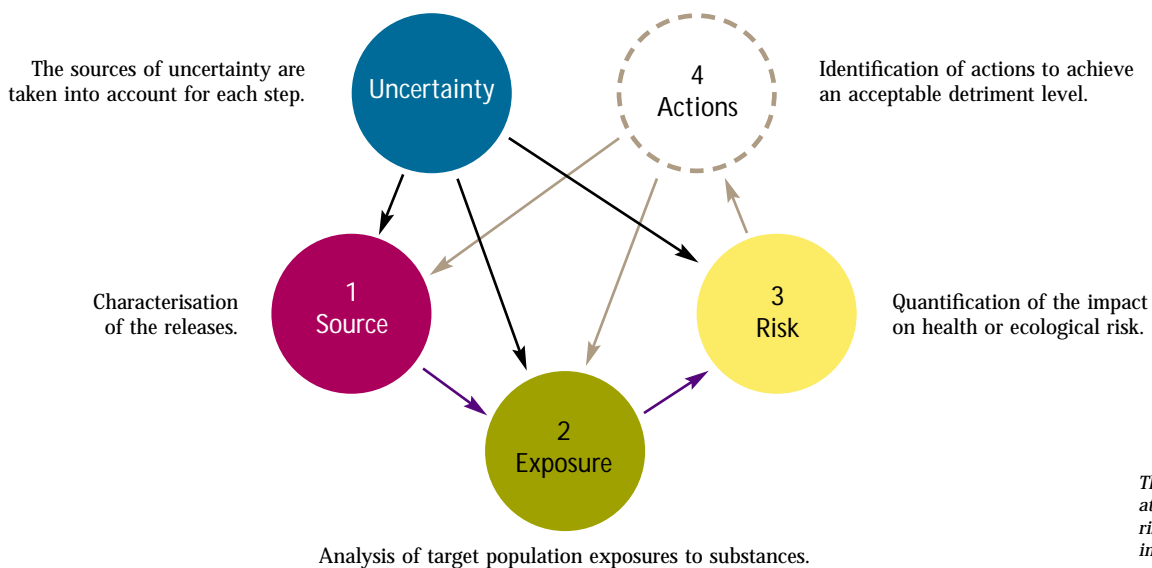
A parallel with ecotoxicology

ENVIRHOM and SYMBIOSE programmes are two complementary programmes used to assess the ecological risk linked to radioactive substances. Since ecotoxicology has for a long time formalized methods assessing the ecological risk associated with the presence of chemical poisons, a parallel with this area was initiated and particularly, results in collaboration with INERIS. In fact, in many cases of risk assessment, chemical contaminants and radioactive contaminants cannot be considered separately.

A STRONG INVOLVEMENT IN INTERNATIONAL PARTNERSHIP NETWORKS

In addition to these research actions, IRSN participates in the European FASSET programme. Its main objective is to propose systems to assess the impact of radioactive contamination on the environment due to accidental or chronic releases linking the release scenarios, the routes of exposure, the doses to biota's (live organisms) and the effects which may result from these. As a single European programme dealing with environment protection issues in a practical way, FASSET mobilizes 15 teams from 7 European Union countries. This work will be pursued within the framework of the European ERICA project in which IRSN takes part. In the end, the ERICA project shall lead to a method assessing the risk associated to the presence of radionuclides in the environment. Lastly, IRSN has been actively engaged in the work of different study groups on the protection of the environment, implemented by international organisations (ICRP, AEN, UNSCEAR, IAEA...).

BREAKDOWN OF THE ASSESSMENT AND RISK MANAGEMENT CYCLE



The Symbiose programme aims at assessing and managing the risk of radioactive contamination in the environment.

> IRSN research programmes in marine radio-ecology

IRSN expertise regarding the assessment of the impact of radioelements present in the environment, on human beings and ecosystems, implies in particular the understanding and quantification of the transfer mechanisms of the natural and artificial radioactive substances in the marine environment. For more than twenty years, the Institute has been conducting marine radioecology studies, bringing together specialists in chemistry, biology, geochemistry, sedimentology... Relations were established with French and foreign research and expertise organisations (participation in working groups, signature of collaboration agreements).

62 days of campaign at sea in 2002

The data obtained during sampling campaigns in sea and in the estuaries are used to design and validate transfer models. The purpose of those models is to assess the dispersion in the marine environment – seawater, sediment, biota – of the radioactive substances of natural or artificial origin.

These campaigns use IFREMER and CNRS/INSU (Institut National des Sciences de l'Univers) resources. IRSN's access to oceanographic ships and their equipment depends on the assessment conducted by an appropriate scientific committee for both institutes in research projects involved. The requests submitted in 2001 by IRSN led to the scheduling of six campaigns in 2002, for a duration of 62 days at sea.

These campaigns contributed to:

- Understanding and quantifying transfer mechanisms between the sea, the atmosphere, ^{14}C and tritium soil (TRANSAT¹ campaign);
- Developing a model of dispersion at sea for contaminants, in the near field of an emission source (DISPRO² campaign) ;
- Understanding and quantifying the fixation and remobilisation mechanisms of radioelements in sediments (DIAPLU³ campaign) ;
- Studying the distribution of natural and artificial radioelements contributed by the Rhône River to the Mediterranean (REMORA⁴ campaign).

1. TRANSAT : TRANSfert eau ATmosphère.
2. DISPRO : DISpersion en champ PROche.
3. DIAPLU : comportement du PLUtonium dans la DIAgenèse des sédiments marins.
4. REMORA : REMObilisation des RADionucléides dans le pro-delta du Rhône.

Improve the knowledge concerning transfers between the sea, the atmosphere and the soil

The work of the Nord-Cotentin Radioecology Group (GRNC) showed how important it was to deepen knowledge in the area of transfers between the sea, the atmosphere and the soil. This led IRSN to conduct research on the understanding and quantification of transfers between those three compartments. The purpose of both TRANSAT campaigns carried out in February and August 2002 was to quantify the transports of ^{14}C and tritium in gaseous form between the water, the earth and the atmosphere, in the ecosystems of the central Manche and the Seine river estuary. Moreover, the results obtained on ^{14}C during these campaigns will contribute to the more general study of the CO_2 cycle within the framework of the work on climate change. The equipment and specific techniques developed during these campaigns are used to measure very low levels of ^{14}C and tritium in the air.

These campaigns were conducted in collaboration with the Laboratory of Science of Climate and the Environment (LSCE, CEA/CNRS mixed unit) and the Group of atomic studies (GEA) of the National Navy.

Towards the modelling of contaminant dispersion in the English Channel.

The purpose of both DISPRO campaigns carried out in November 2002 was to determine the short and medium-term dispersion parameters of soluble releases in the sea through tides using the tritium controlled releases of the La Hague power plant in the North-West of the Cotentin region. They will allow the dispersion variations to be better assessed, depending on hydrodynamic conditions (release time, tidal currents, meteorological forcing). The results obtained on the tritium used as a tracer will be used to validate a high-resolution two-dimensional dispersion model (110 metres), developed in collaboration with IFREMER. 4,000 seawater samples have been collected, as well as data on sea currents and depths. The first results show that tritium concentrations measured in seawater correspond to those provided by the model.



DIAPLU mission: the Flucha core sampler takes samplings for analyzing sediment.

Study the resuspension conditions of plutonium in sediments

The DIAPLU campaign took place in the Irish Sea from 2 to 21 July 2002. It was part of a research project intended to determine through which processes plutonium, fixed in sediments marked by reprocessing plant releases, can be mobilized towards water.

In fact, sediments constitute a deferred and non-point plutonium source that will be taken into account to assess the plutonium part linked to a release and the plutonium part coming from the remobilization of plutonium contained in sediments. Plutonium concentrations found in Irish Sea sediments marked by releases from the Sellafield reprocessing plant enable the plutonium dissolved in interstitial waters of sediments to be measured. Sampling of sediment cores and extraction of interstitial waters were performed in conditions keeping the physical and chemical characteristics of the studied environments.

The analyses of the 230 samples were used to determine their sedimentological and geochemical characteristics as well as the characteristics of the interstitial waters (pH value, redox potential...). The association modes of plutonium with the solid and reactive phases of sediments were determined and the concentration of plutonium dissolved in interstitial waters was assessed.

This campaign was performed within the framework of the REMOTRANS programme of the European commission, with the collaboration of the CEFAS (The Centre for Environment Fisheries and Aquaculture Science, UK) and the University College of Dublin (Department of Experimental Physics, Ireland).

Study of the Rhône River influence on sediments in the Mediterranean

REMORA campaigns study the influence of the Rhône River inputs on the transports of natural and artificial radioelements as well as trace metals in the Mediterranean. They are particularly used to assess the temporal development of concentrations and quantities accumulated in sediments of the Rhône River submarine delta (pro-delta). The freshwater/salt water mixing area is the heart of complex phenomena of aggregation, flocculation and precipitation. Those fixation phenomena generate a low dispersion of radionuclides in seawater and their accumulation in the Rhône River pro-delta sediments. Resuspension phenomena, especially during east wind storms and Rhône River floods contribute to the redistribution of elements temporarily trapped in sediments. Besides, stopping the industrial reprocessing operations of Marcoule (Gard) site since 1997 led the IRSN teams to perform, between 2001 and 2002, sediment sampling campaigns in the Golfe du Lion in order to analyse accurately the environmental response to such a change.

The REMORA 3 campaign, conducted from October 12th to November 5th, 2002, completes the campaigns performed in 2001 in the area under direct influence of the Rhône River inputs (European REMOTRANS programme). Almost 2,400 sediment samples were collected during the three REMORA campaigns.

The REMORA 3 campaign was carried out within the framework of the EUROSTRATAFORM (EUROpean margin STRATA FORMation), ORME (Environment Regional Mediterranean Observatory, CNRS) and PNEC (National Coastal Environment Programme) programmes.



Extraction of interstitial water of sediments sampled in sea.

REMORA mission: localization map of samples.



> Radiation protection of populations and professionals

IRSN is the main French technical organisation aiming at informing citizens, increasing professionals' awareness and advising public authorities on ionising radiation-related risks. Its experience in the area of workers' radiation protection allows it to provide technical advice on draft regulations and take part in the work of various national or international organisations.

An evolution of the regulation

The protection of individuals against ionising radiation is based upon three principles: justification of the practices, optimisation of the protection and limitation of doses. The whole population is concerned but in different ways depending on whether the individual is a worker, a patient or a public figure. Two recent European directives concern radiation protection: "96/29" for workers and the public and "97/43" for patients.

Workers' radiation protection

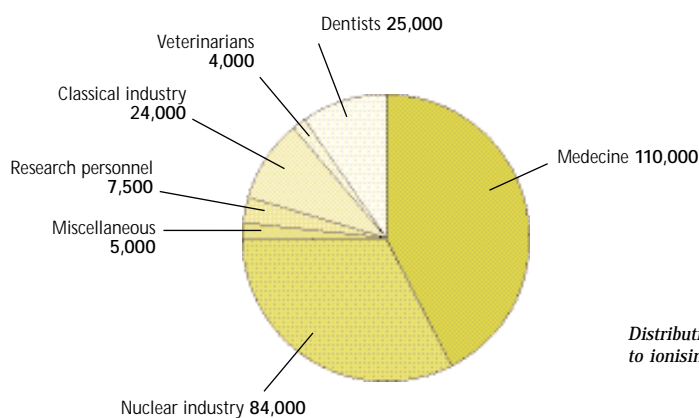
In France, exposure to ionising radiation of 260,000 workers in the medical, nuclear and industrial sectors is monitored. IRSN ensures the dosimetry of 60% of these. To do so, the Institute has laboratories specialised in the monitoring of external exposure (supply and analysis of dosimeters) and internal exposure (radiotoxicological analyses and anthropogammametry). Furthermore, IRSN provides expertise in work stations, in order to reduce professional exposure. In 2002, IRSN ensured the distribution and treatment of 1,900,000 dosimeters.



IRSN ensures the dosimetric monitoring of workers exposed to ionising radiation.

SISERI

To record, check and report the doses received by workers exposed to ionising radiation are the main objectives of the SISERI database. Developed by the Institute since 2000, it is intended for use by various radiation protection actors (occupational health physicians, "certified" persons in companies...). Ultimately, current developments will allow remote access to data, via a secure Internet network.



Distribution of the 260,000 workers subject to a monitoring of their exposure to ionising radiation.

Patients' radiation protection

IRSN takes part in the development of future regulation related to the protection of patients, based upon the reduction of exposures at an optimal level, while ensuring the quality of the diagnostic images and the achievement of the therapeutic objectives. Its expertise focuses on the justification of actions, protection optimisation, equipment quality control, medical screening campaigns and training of professionals. Within this framework, the Institute took part in the preparation of a report on the procedures and reference doses of radiological examinations. This system of reference aims at reducing the dosimetric differences noted for the same examination.

Furthermore, in radiotherapy, IRSN conducts research on biological indicators which will enable the assessment of the radiosensitivity of each patient in order to adjust therapeutic protocols. Studies on mechanisms of induction of side effects have also been conducted in order to suggest appropriate treatments.

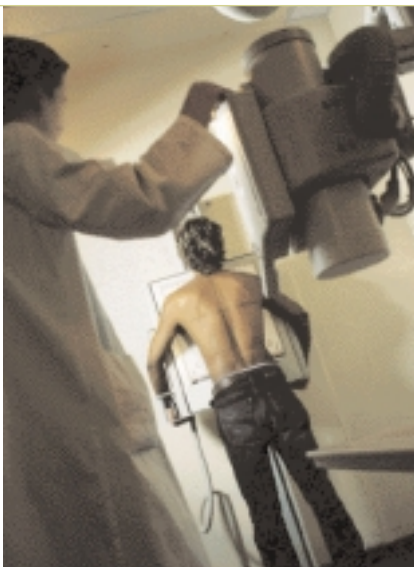
Exposure to cosmic radiation

To implement the 96/29 directive, the SIEVERT system was developed by IRSN, and its partners, the General Directorate of Civil Aviation (DGAC), the Meudon (Hauts-de-Seine) Observatory and airline companies, to provide necessary information about cosmic radiation exposure in planes and assess radiation doses received during a

flight. SIEVERT has been opened to French airlines since August 2001 for the regulatory dosimetry of their staff. To date, more than twenty airlines have used this system and the doses have been calculated for almost 1 million flights. This service was also opened to the public in March 2002 and it is available on Internet (www.sievert-system.org).

Control of radon in homes

Radon is a natural radioactive gas which is classified among the carcinogenic substances for lungs. For more than 25 years, it has been studied by IRSN which has provided elements to public authorities in order to develop a prevention policy of the related risk. Thus, the Institute produced a map of radon concentrations, published in 2000, after performing more than 12,000 radon measurements in French homes, in collaboration with departments of the Ministry of Health. To enrich this map, complementary measurements were performed in 2002 in eight departments and the analysis of those results is currently in progress. Furthermore, a cross analysis of the measurements with INSEE data (population density, types of homes, seasonal behaviour...) was carried out in 2002 and it will be used to assess the radon exposure of the French population in terms of concentration measurements.



IRSN brings its expertise to patients' radiation protection.



The modelling work intended to distinguish radon from a mining site from radon of natural origin.

By reducing the threshold of public exposure to radiation generated by industrial practices, French regulation based on the 96/29 European directive posed the problem of the distinction between radon of natural origin and radon originating from residue storage of uranium mines.

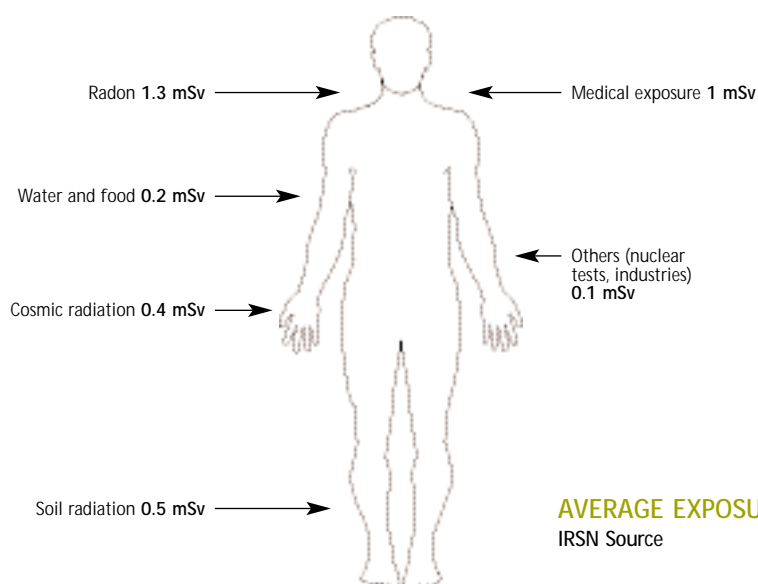
IRSN performed several measurements of radon and its daughters, mainly bismuth 214 (^{214}Bi), as part of a research programme conducted in the Bessines-sur-Gartempe (Haute-Vienne) mining site and its surroundings. The bismuth/radon ratio proves to be far lower in the immediate site surroundings than in the outlying environment. This phenomenon is mainly linked to atmospheric dispersion, for which we have working models which schematically predict that the bismuth measured in the surrounding site is representative of the radon of natural origin only. From the measurement of total radon, the part of radon of anthropogenic origin emitted by the mining site may therefore be deduced.

In 2002, the method was improved, the physical hypotheses and simplifications of the models used were subjected to a critical analysis. The uncertainties related to these hypotheses were assessed. Nowadays, IRSN uses a method applicable to similar sites whose characteristics correspond to the validity area of the method.

Measurements of radon and free fraction of its daughters

Pure metrology work on radon gas is intended to provide reference values and ensure proper traceability of the gas during the calibration of equipment. Within this framework, IRSN participated in an international intercomparison, concerning the calibration procedures, launched in 2002. Measuring equipment, called Alphaguard, circulated in 9 European laboratories which performed its calibration. This exercise showed good consistency in the results obtained by the different laboratories.

The radon gas metrology is specifically completed with the measurement of the free fraction of its daughters, small aerosols (about one nanometre) contributing to the health risk. In 2001, the Institute launched a partnership with the University of Catalonia (Spain) and the University of Brest (Finistère) for the development of original measuring equipment, intended for the characterisation (measurement of particle size) of radon daughters and particularly polonium 218. In 2002, the two organisms carried out an intercomparison of two measuring systems of the free fraction of radon daughters. The resulting analysis is currently in progress and the first elements analysed show satisfactory consistency, with some points to be improved, in particular data processing algorithms.



AVERAGE EXPOSURE OF THE FRENCH POPULATION
IRSN Source

> IRSN participation in ICRP work

IRSN experts participate actively in the work of the International Commission on Radiological Protection (ICRP) at a crucial moment in the action of this organisation, aiming to simplify and clarify the radiation protection system in order to make it more comprehensible and more efficient. The recommendations from this work will complete publication 60 dated 1990 which is used as a reference for basic international standards of the International Atomic Energy Agency (IAEA) and for the European directive of 1996 on radiation protection of workers and the public.

The ICRP, which was created in 1928 as a non governmental organisation, plays a crucial role in the development and transmission of the protection principles against ionising radiation. The Commission closely work with the International Commission on Radiological Units and Measurements (ICRU) and keeps relations with many other international organisations, including the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

The mandate of the ICRP members has just been renewed for the 2001-2005 period. IRSN is represented in the main Commission by Annie Sugier, Director for Protection of IRSN, who has just been designated as President of the technical committee on the application of recommendations, succeeding to the South-African Bert Winkler. The following IRSN experts also take part in the different technical committees of the ICRP: Margot Tirmarche (Committee 1 – Radiation effects), Henri Métivier (Committee 2 – Derivate limits), Jean-François Lecomte (Committee 4 – Application of recommendations).



ICRP members during the meeting held in September 2001 at La Haye.

> Expertise and research in neutron dosimetry

With time, IRSN has developed a significant and recognized activity of research and expertises in the area of neutron dosimetry. Equipped with metrology and test installations, some being unique in the world, the Institute has a reference position both at national and international levels.

Research and study activities Measurements and characterisation of radiation fields in work places

The purpose of the measurements is to assess workers' exposure to neutrons, in order to improve their radiation protection, suggesting practices and instruments more appropriate to their irradiation conditions. IRSN has conducted many measurement campaigns in France (nuclear industry, army, transports of nuclear materials, radiotherapy, air transports ...), and in foreign countries (Spain, Germany, Belgium). Among recent operations, a measuring campaign of neutron dosimetry was conducted in 2002 in an industrial production facility of MOX fuels operated by COGEMA (ATPu work area).

Assessment of personal dosimeters

The behaviour of the personal dosimeters varies depending on the various characteristics of the neutron radiation field and environmental factors (temperature...). Within this scope, IRSN is involved in two European programmes. The first programme, called EVIDOS, focuses on the assessment of various available or in-study methods for ensuring the personal dosimetry of workers, in the real exposure conditions found in work stations ;

from October 14th to 18th, 2002, the EVIDOS programme participants were gathered around the CEZANE and SIGMA facilities in order to calibrate the equipment used for this programme. The second programme, conducted within the framework of EURADOS (European Radiation Dosimetry Group), aims at harmonizing the dosimetric practices in Europe; IRSN is responsible for conducting

a state of the art study of the development and use of personal electronic dosimeters.

Calibration of dosimeters with reference radiation sources

The calibration of dosimeters is performed by the IRSN laboratory certified by the COFRAC (French Committee for Accreditation) and concerns photons and neutrons. As a laboratory associated with the National metrology bureau (BNM), IRSN plays the role of national reference for neutron dosimetry. It is part of the cooperative organisation between the national metrology institutes, EUROMET, and is recognized at the international level by the International Bureau of Weights and Measures (BIPM). As such, IRSN organizes comparisons with other laboratories at the national and international levels.

Research and development of new measuring instruments and methods.

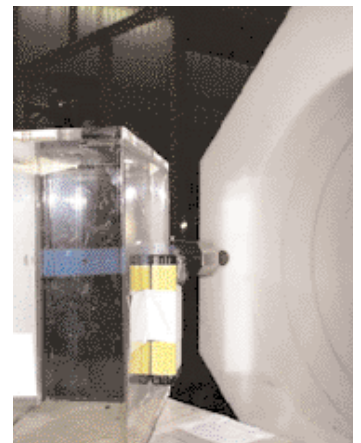
The purpose of research and development actions is to improve the monitoring of workers' exposure.

The research of new measuring methods is conducted with scientific software used to simulate the experimental conditions studied.

Models and laboratory prototypes are then made and tested on reference installations. Having neutron, but also photon, references is crucial for IRSN to conduct research and perform expertise as neutron fields are always associated with photon fields in work places. In June 2002, a French industrial company marketed the first electronic dosimeter called "Saphydose-n" for measuring neutron radiation. This has put into effect the success of a study and a technology transfer conducted by IRSN, following previous work carried out in its laboratories. This dosimeter, whose first industrial prototype was validated during the measuring campaign conducted by IRSN in the EDF power plant of Dampierre-en-Burly (Loiret), was certified in January 2002 by the CTHIR (Technical Centre for the Approval of Radiological Protection Instrumentation).

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Years of research were required to develop the first electronic dosimeter for neutrons meeting the international standards requirements.



First EVIDOS campaign on CANEL: Saphydose-n.



IRSN has unique tools in France for neutron dosimetry such as the CANEL moderator device shown here.

Participation in national and international normative bodies

IRSN experts participate in national (Standardization Bureau for Nuclear Equipment (BNEN)) and international bodies, such as the International Organisation for Standardization (ISO) and the International Electrotechnical Commission (IEC) working groups. For ISO, the activity in 2002 focused on the creation of a new standard concerning the calibration in neutron radiation fields with "realistic" spectrums. The IEC committee on radiation protection instrumentation, managed by IRSN, met in Beijing (China). One of the working groups in which IRSN participated actively examined personal and area electronic dosimeters.

Unique installations in France

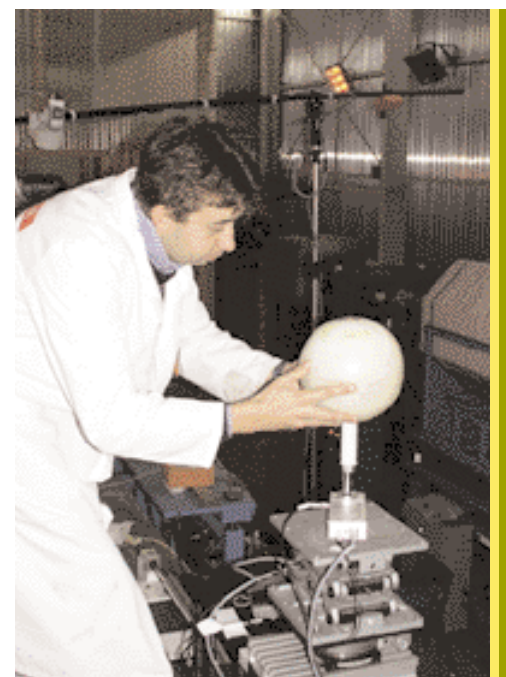
IRSN reference means for neutron dosimetry are located in Cadarache (Bouches-du-Rhône). Those means, unique in France, exist in two facilities: CEZANE and SIGMA. The CEZANE facility houses the Van-Gogh irradiator, comprising three sources emitting neutrons of intermediate and high (fast neutrons) energy. The SIGMA facility comprises a source emitting low energy neutrons (thermal neutrons).

Moreover, the CEZANE facility houses two electrostatic accelerators coupled to a moderator device called CANEL. This equipment is used experimentally to produce neutron radiation whose energy distribution is said to be "realistic", *i.e.* representative of the conditions observed in work stations. They are used to assess the performances of dosimeters and detectors in various configurations. Within the framework of a EUROMET (European Metrology) collaboration between IRSN, the German (PTB) and English (NPL) primary laboratories and the University of Barcelona (Spain) (UAB), the characteristics of the radiation field produced by a new configuration of the CANEL device were determined in 2002. This device, unique in the world, is also intended to become a reference as an international standard project on the production and use of "realistic" spectrums, currently being assessed by ISO.

A NEW INSTALLATION DEDICATED TO MONOENERGETIC NEUTRONS

In 2000, IRSN decided to acquire a new equipment to produce monoenergetic neutrons of metrological quality: the AMANDE project, whose equipment will be implemented near the CEZANE facility. This new equipment will be used to study precisely the behaviour of radiation protection instruments depending on the neutron energy, positioning them in a neutron field with well defined and precisely determined energy, and making energy vary also in a perfectly controlled manner. The implementation of the AMANDE project implies the construction of an accelerator (being manufactured by the Dutch company HVEE), the request of authorisation for operating a facility classified for the protection of the environment (registered in the Prefecture of the Bouches-du-Rhône in July 2002) and the construction of the building which will house the accelerator and its test hall (start of work scheduled in 2003). According to current planning, the accelerator reception in plant should occur in the course of 2003 and its implementation on site in 2004. Following a test period, operational production would start in 2005. In 2002, many communication actions were carried out, especially for the public inquiry required before obtaining the authorisation for use.

With the AMANDE installation, IRSN will have a complete set of metrological installations for neutrons and photons, which will cover all the needs for calibration and qualification of the radiation protection equipment used to ensure the dose monitoring of workers in the civil and military nuclear industry and the medical field.



Installation of neutron measuring equipment on a Van-Gogh calibration system.

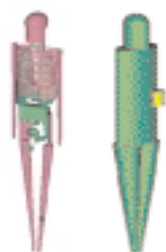
> Management of accidental exposures

During irradiation or contamination accidents or incidents, IRSN may have to contribute its expertise to assess doses received by irradiated persons and to assist medical teams in charge of their treatment. Concurrently, the Institute continues its research to improve diagnostic indicators – especially by developing new techniques for dose assessment – and to optimise treatment of irradiated persons.

Complementary missions

In case of accidents, the assessment of the dose received by an irradiated person is an important element to choose the appropriate therapeutic strategy. This expertise work is based on several complementary approaches, but it is essential to collect the maximum information about the circumstances of the accident and the exposure conditions of the victims. Biological dosimetry is used to assess the average dose received by an irradiated person from the scoring of unstable chromosome anomalies in the circulating blood lymphocytes, by a cytogenetic technique referred as conventional. Physical dosimetry is used to assess the distribution of doses in the organism from experimental reconstructions or by modelling of the irradiation conditions. The dose received can also be assessed with measurements by paramagnetic electronic resonance on bone fragments. In case of contamination, the incorporated activity, and therefore the dose, may be assessed, depending on the radionuclides, from the anthropogammametry or measurement performed on urine and stools.

In addition to work aiming at improving the previously mentioned measuring and assessment techniques, the main purpose of research conducted by the Institute in the management of the accidental exposures is to suggest treatment appropriate to each situation encountered, by taking into account the radiosensitivity of each individual and the heterogeneous characteristic of the irradiation accidents.



*Dose reconstruction in case of accident:
modelling of the irradiated person and the source.*

National incidents

Roissy (Val-d'Oise)

A defective package containing radioactive materials was transported through Charles-de-Gaulle Roissy airport. IRSN conducted expertise studies using biological dosimetry for the nine persons who had handled the package for unloading, storage and reloading in the aircraft. To obtain very accurate results, 2,000 cells were analysed, instead of the usual 500. The number of instable aberrations detected was abnormally high for three of these persons, but the confidence interval of the dose received could be separated from the background level for one of them only. Moreover, no effective relation with the transportation of the damaged radioactive package could be established.

Bordeaux-Gradignan (Gironde)

Upon the request of the Director for the Prevention of Pollution and Hazards, IRSN conducted an expertise study of the incident which occurred on January 25th, 2002, on one of the experiment lines of the Van-de-Graaff accelerator from the Centre of Nuclear Studies of Bordeaux-Gradignan (University of Bordeaux 1). This incident implied an exposure to tritium of a dozen of persons present in the related premises. The contamination level of those individuals was assessed from tritium measurements in urines performed by OPRI. The incident analysis allowed the possibility of drawing lessons to reinforce the security of this type of equipment. The suggested improvements concern the technical devices used to prevent accidental tritium degassing, the collect and control of tritium releases and the protection of staff and monitoring at the work place.

Ladoux (Puy-de-Dôme)

IRSN took part in the technical analysis of the irradiation accident which occurred in the Michelin plant at Ladoux (Puy-de-Dôme) in June 2002, when three workers entered a bunker dedicated to an industrial electron accelerator for a maintenance operation. The equipment operator accidentally activated the electron beam, which generated the production of bremsstrahlung X-rays. Moreover, IRSN conducted a biological dosimetry expertise study which did not reveal any significant exposure of the workers concerned.

Mobilization of IRSN agents to treat a great number of blood samples.



International incidents

Georgia

In December 2001, three Georgians handled strontium electricity generators. Suffering from severe burns and a collapse of their bloodlines, they were hospitalised in Tbilisi (Georgia) three weeks later. One of them had very severe injuries in his back.

IRSN intervened upon the request of IAEA and recommended the transfer of the most injured patient to France. He arrived in Paris in February 2002, 88 days after the accident. He was taken in charge at the Army Hospital of Percy (Hauts-de-Seine), where he underwent several transplants. The improvement of his health condition permitted him to return to Georgia in April 2003.

IRSN provided its support to hospital teams, particularly in performing dosimetric assessments. Two biological dosimetry methods were used. The assessment of the average dose by the conventional cytogenetic technique was completed by the evaluation of the dose received at skin level, a technique applied for the first time in an accident. This second dosimetry was performed by scoring the stable translocations using the FISH (Fluorescence *In Situ* Hybridization) method. The dose estimates are in agreement with the clinical data. Lastly, a dose calculation, using a modelling of the source and the patient, confirmed the consistency of the various analyses.

Poland

Upon the IAEA's request, IRSN intervened in 2002 in Poland, in the management of the consequences of a radiotherapy accident having occurred in February 2001, involving five patients. After a clinical expertise, the most injured patient was transferred to France and treated in the Curie Institute. She was able to return in Poland after undergoing several transplants. For three of the five patients, a dosimetry by electronic paramagnetic resonance was performed on a rib fragment sampled during the surgical resection in the irradiated area. The results of those measurements were used to refine the therapeutic strategy by confirming the possibility of transplant.

Collaboration with the Saint-Antoine hospital on the research of therapeutics in haematology.

In 1999, IRSN created, with the Saint-Antoine university hospital centre (Paris-VI University), a common laboratory called Laboratoire de Thérapie Cellulaire et de Radioprotection Accidentelle (LTCRA). Its goal is to perform experimental research in order to improve the treatment of bone marrow failures, due either to accidental irradiation or not, using cell therapy. This therapy consists in multiplying the cells of a patient taken from his own organism and then re-injecting them when he or she needs them. This technique, applied to haematopoietic stem cells sampled after an accidental irradiation in a medullar area more or less protected from irradiation, has shown very promising results in the treatment of radiation-induced aplasia. This technique is being applied for other cell types, and especially for mesenchymal stem cells which, after re-injection, are able to acquire the functionality of the organ or tissue they colonize.

An aplasia patient was treated with this technique in 2002. This work was published in international reviews.

20
IRSN performed 20 expertise studies using biological dosimetry for accident suspicions in 2002.

International intercomparison of dosimetry on the Silène reactor: positioning of blood samples.



> Understanding the ionising radiation effects

The work conducted on health effects of ionising radiation is crucial to achieve the radiation protection missions of the Institute. It will improve the knowledge on issues where uncertainties remain.

Analytic epidemiological studies

The purpose of these studies, concerning workers and populations exposed to ionising radiation, is to better quantify the risk of developing cancer depending on the dose received. Two methods are used: prospective surveys are used to follow over time the evolution of the disease rate within a group of exposed persons, while the case-control studies are used to establish a comparison between the exposure of individuals suffering from a pathology and the exposure of a "control group" not suffering from this pathology. IRSN is currently pursuing studies with these methods:

- Monitoring of the cohort of workers from the CEA-COGEA group within the framework of an international study conducted by the IARC (International Agency for Research on Cancer);
- Monitoring of the cohort of 5,098 French uranium miners exposed to radon, completed by a case-control study within this cohort to study the joint effect of radon and tobacco;
- Case control study on lung cancer within populations exposed to domestic radon including 1,655 individuals (552 cases and 1,103 controls) in 4 French regions;
- Study of the health consequences of the Chernobyl accident, in particular within the framework of the French-German initiative, and case-control study of the risk of leukaemia within populations living in contaminated territories on the banks of the Techa River (Urals).

Concurrently, IRSN takes part in the RIMED project (Ionising radiation in medical environment): epidemiological monitoring of the death rate among health care professionals exposed to ionising radiation in France. Started in 2002, the feasibility study, coordinated by InVs,

will concern 6 hospital institutions. IRSN brings to this project its experience in the epidemiological monitoring of an active population and the management of professional and dosimetric databases.

Lastly, with the intent to develop epidemiological studies on patients exposed to ionising radiation for medical purposes, IRSN started a pilot study in 2002 on 100 premature infants subject to repeated examinations during the neonatal period. The purpose of this work, conducted with the Trousseau Hospital, is to determine how accurate the doses received by those infants may be evaluated, and to assess the relevancy and feasibility of epidemiological monitoring of the related population.

Effects of chronic radionuclide ingestion

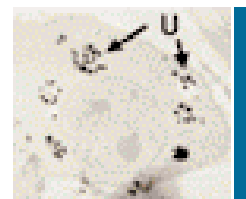
In order to improve the assessment of the risks linked to the chronic low level incorporation of radionuclides, IRSN launched the ENVIRHOM programme in 2000, focusing on both biological components of the environment and human beings. The "human" part of this programme is conducted along four lines:

- Researching the phenomena of chronic accumulation of the radionuclides;
- Understanding of the biological mechanisms leading to the phenomena observed;
- Analysis of the biological effects on the immune system, the digestive system, the central nervous system and the reproduction system;
- Implementation of new biokinetic and dosimetric software and models in order to assess the uncertainties on the doses received and better take into account the cellular distribution of the radionuclides.

In 2002, work was focused on the first two areas and a part of the third area, the study of the biological effects on the digestive and central nervous systems, with uranium as radionuclide using the rat as the animal model. The study of the consequences resulting from uranium chronic accumulation on the fertility and embryonic development of rodents, as well as on the organism's capacity to respond efficiently to situations frequently encountered in public health (bacterial infections, alimentary antigens, etc.) will be performed in 2003.

17,500

Number of analyses performed within the framework of the ENVIRHOM research programme intended to assess the risks of radionuclide bioaccumulation.



Heterogeneous distribution of uranium in a kidney proximal tubular cell.

Effects of acute irradiations

The work performed in this area concerns both the severe effects caused by an accidental exposure, and the long-term deleterious effects resulting from therapeutic exposures. Historically, the studies performed by IRSN focused on the development and operational application of biological dosimetry using classical cytogenetics (dose assessment from the scoring of chromosome aberrations) on the one hand, and on the other hand, the study of the radiation induced dysfunctions of the physiological systems involved in the vital prognosis of the irradiated person: haematopoietic system, digestive system and central nervous system. These studies took into account significant scientific advances which occurred in biology in recent years. Today, considering these studies and the lessons drawn from the severe irradiation accidents having occurred around the world, IRSN research activities gradually evolved towards the following topics:

- Operational application of new biological dosimetry methods to assess the dose received whatever the irradiation typology. Within this framework, dosimetric assessments were performed on skin pieces sampled during surgery on a Georgian patient and on a Polish patient severely irradiated, treated in the Burn Treatment Centre (Percy Hospital) and in the Curie Institute. The results have proven to be particularly promising for characterizing the extent of injuries in case of localised irradiation;
- Physiopathology of the effects caused by an accidental irradiation or by the irradiation of healthy tissues during medical examinations or treatments. The purpose is to identify biological indicators of diagnosis and prognosis of the radiation induced pathologies and to

LIMITING THE SIDE EFFECTS OF A RADIOTHERAPY

Radiation therapy treatments generally deliver high doses necessary for the tumour monitoring, but also irradiate healthy tissue contiguous to the cancerous tissue. They may cause very disabling side effects for patients. On this topic, still poorly appraised, IRSN pursues research, especially in the laboratory operated in collaboration with the Gustave-Roussy Institute, in order to better understand the mechanisms implied in the initiation, development and persistency of those side effects. The objective is to suggest preventive or curative therapeutic strategies. The work initiated in 2002 focuses on chronic radiation enteritis.

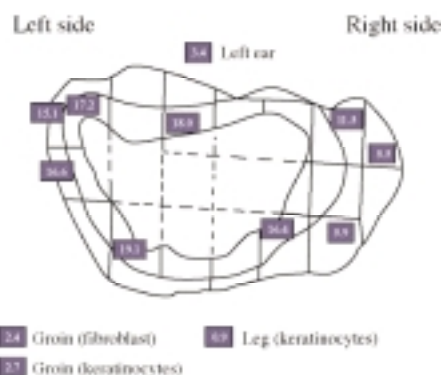
determine possible therapeutic actions. The tissues studied are mainly the vascular endothelium, the intestinal barrier and the skin, given their possible role in the multi-organ failures observed;

- Development of strategies for treating radiation induced pathologies filling the cellular deficits using cellular therapy. This work enables IRSN to bring expertise to the medical teams treating accidentally irradiated persons or treating patients using radiation therapy.

All this research on health effects of ionising radiation conducted by IRSN do not cover all the inquiries related to this subject, in particular those related to carcinogenesis. However, they provide IRSN with a privileged position to develop cooperative research at national and international levels.



Scoring of chromosome aberrations with microscope.



Biological dosimetry: mapping of the dose received at skin level for one of the patients irradiated during the accident in Georgia.

IRSN

Contributing to the safety of nuclear facilities — and transports



Paluel unit for nuclear electricity production.

750

Technical notices transmitted by IRSN to safety authorities in 2002.

13

In 2002, IRSN submitted 13 assessment reports to the French Advisory group of Experts for nuclear reactors.

133

In 2002, IRSN transmitted 133 technical notices related to the safety of the transport of nuclear materials.

Helping to prevent accidents in nuclear facilities or during transport and limiting the consequences of accidents which might nevertheless occur is a major concern for IRSN.

Assessing the safety of nuclear facilities and transports requires at all times technical knowledge, given the evolution of facilities and the safety approach: aging of equipment, evolution of fuels, severe accidents, waste management, prevention of criticality risks, fire protection... For these technically complex issues, the Institute develops and uses its competencies in the areas of studies, expertise and research. Researchers and experts have the same global objective: assessing the risks to better control them and prevent their consequences.

The whole approach implies safety assessments and studies used to identify issues insufficiently known as well as research intended to increase the knowledge. Within this framework, the Institute has for many years developed probabilistic safety analyses (PSA) applied to the PWRs, which are used to assess the probability of an important event for safety and its consequences.

The research studies have in particular resulted in an interaction between the development of analytic models, the development of software and the carrying out of experiments in realistic conditions.

The competencies acquired by the IRSN in the areas of expertise and research are also used for non nuclear facilities. The Institute makes available to the industry improvements of its competencies.

> Phénix safety review

Put into service in 1974, the Phénix reactor is a fast neutron reactor, with sodium cooling systems. Owing to the age of the facility and CEA (Atomic Energy Commission) wishes to continue to use it for several years, since 1997 the licensee has begun a renovation programme including significant improvements in the resistance to earthquakes and sodium fires.

Significant work

The core internal structures, sodium circuits, emergency equipment were controlled, and, in some cases, repaired on the basis of a general assessment of the equipment aging. The requirements regarding the resistance of nuclear facilities to earthquakes, were also redefined and the buildings were thus reinforced, involving a significant building project.

Risk analysis

In view of a possible restart of the reactor in 2002, IRSN studied CEA proposals regarding methods intended to control and analyze failures as well as repairs of the steam generator modules affected by a cracking phenomenon specific to the stainless steel used for their construction. Concerning the safety of steam generators, the licensee's justifications were studied according to an approach which identified the existing in-depth lines for each important safety event.

Other issues were studied, in particular those concerning the risks in case of sodium fire and the in-service monitoring of the upper part of the reactor vessel. The structure supporting the control rods (plug-cover-core) was particularly studied, as well as the consequences of

an accident of instantaneous plugging of a fuel assembly which is a possible initiating event of partial core meltdown.

IRSN submitted the results of its analyses to the French Advisory group of Experts for nuclear reactors in October 2002. This meeting was the last of a series of eight meetings held since 1996 within the framework of the safety review of the nuclear facility.

Among other issues studied in 2002, the Institute highlighted the need for the licensee to have more efficient procedures and tools for the management of crisis situations.

Another important issue in 2002 was the study of the fire action plans for each building. In fact, these plans were completely revised by the licensee, taking into account the renovation work performed. Several failure common modes of materials important for safety were thus identified and processed by the licensee. These actions have been continued in expectation of a power increase of the reactor.

It is important to recall that the residual operating time of the Phénix reactor is a maximum of six operating cycles during which the CEA (Atomic Energy Commission) planned to perform various irradiation experiences, within the framework of partitioning-transmutation work, under the law of December 30th, 1991 regarding the management of high activity and long-life radioactive waste.

7
In 2002, IRSN transmitted 7 technical notices concerning the safety of the Phénix fast neutron reactor and wrote a report for the French Advisory group of Experts for nuclear reactors.



Phénix in Marcoule.

*Saint-Alban unit
for nuclear electricity
production.*



> Studying the safety of PWR fuels

IRSN provides technical notices on new developments in fuel management requested by Electricité de France in order to reduce production costs. The Institute has to carry out studies and research programmes to assess the impact of fuel evolution on safety.

Technical stress related to economic issues

Economic considerations lead most of the electricians in the world to strive for an increase of the burn up fractions of the nuclear fuel they use in their facilities.

In this framework, EDF was allowed in 1998 to use the uranium oxide (UO₂) based fuel to a burn-up a fraction of 52,000 MWj/t on average per assembly (instead of 47,000 MWj/t previously). For the future, it forecasts maximum burn up fractions that could reach, or even exceed, 60,000 MWj/t.

Some electrical utilities companies, such as EDF, have for over 10 years, also used MOX type fuel (mixture of uranium oxide UO₂ and plutonium oxide PuO₂). The average burn up fraction of MOX fuel is today, in practice, limited to 45,000 MWj/t according to its use instructions.

The increase of the MOX burn up fraction is also an industrial objective for EDF.

13

IRSN performed 13 expertise studies related to the development of new fuel on behalf of safety authorities.

These evolutions led the Institute to organize, at the beginning of the 1990s, a revision of the available knowledge on fuel behaviour around the world. This highlighted the lack of knowledge concerning the behaviour of fuels with high burn up fractions (exceeding the authorised value set to 47,000 MWj/t) and the need to study the

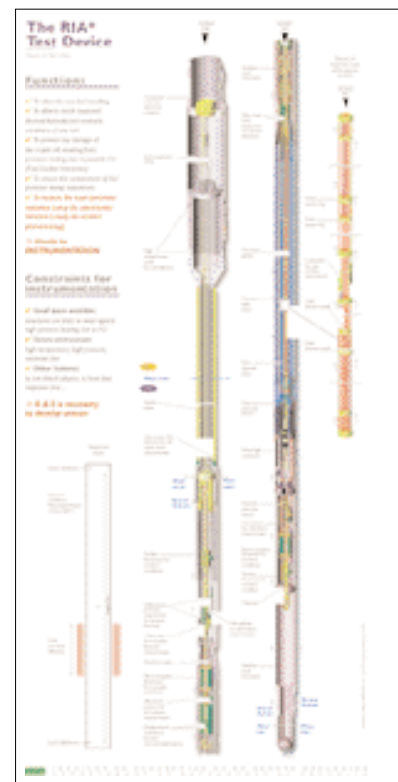
validity of the safety criteria in case of postulated accidents, such as the loss of coolant accidents and reactivity accidents in control rod ejection.

Increasing needs in terms of analysis

Another consequence of the increase of the fuel use rate is to stagger the maintenance shutdowns of the reactors, adjusted on the fuel use cycles. This requires studying the consequences of the new practices from the safety viewpoint. IRSN in 2002 undertook to analyse a feasibility case concerning the "parity" use of UO₂ and MOX fuels, implying a rise of the burn-up rate of MOX fuel up to 52,000 MWj/t.

The analysis focuses on the fuel evolutions likely to have an effect on its behaviour in operation: evolution of the assembly design, use of new structural or cladding materials. In 2002, in the framework of its expertise, IRSN specifically studied a proposal related to the reinforced structure assembly, intended to compensate a failure due to the cladding perforation by "fretting", detected during the cycle N°8 of the Cattenom 3 unit. The cladding corrosion phenomena are also monitored and analysed by EDF.

Assessing the safety of these technological evolutions, in particular the available safety margins, implies developing increasingly sophisticated assessment methods, in particular including three-dimensional thermo-hydraulic or neutron software.



Test device in the water loop.

Research programmes

Research programmes conducted by IRSN study fuel behaviour during postulated accidents: the accident of accidental reactivity injection, with the programmes conducted on the CABRI reactor, and the loss of coolant accident, with a study programme on the irradiated cladding behaviour.

CABRI programmes

The first CABRI programme concerning PWR fuel was initiated in 1993 in the sodium-cooled CABRI reactor loop, in collaboration with EDF and with the support of the NRC (safety authority of the United States). The purpose was to study the behaviour of uranium oxide (UO₂) based and fuels and MOX fuels in a situation of reactivity accident for high burn up fractions. 12 tests, called "REP-Na", were performed in the CABRI reactor, including eight on the UO₂ fuel and four on the MOX fuel. The "in-pile" tests were completed by tests referred to as "separate effect tests" related in particular to the mechanical properties of the irradiated clads and by the development of software known as SCANAIR, used both for the interpretation of test results and their transposition to reactor conditions. The lessons drawn from this programme were used within the framework of the expertise of the files concerning the use of UO₂ fuel to a 52,000 MWj/t burn up fraction.

In order to determine the behaviour of even higher burn up fraction-fuels, IRSN in 2000 launched a new international programme called CABRI-Water Loop, mainly conducted within the framework of the AEN of the OECD.

The tests in the CABRI reactor will be performed in a "water loop" under pressure, more representative of the thermohydraulic conditions characterizing the PWRs than the sodium loop which has equipped this reactor until now.



Two tests of the new CABRI international programme in 2002

In November 2002, the first two tests of the CABRI-Water loop programme were carried out. These are reference tests, conducted in the existing loop cooled by liquid sodium, before being replaced by the water loop and the reactor levelling. The first test showed no sign of clad failure: the analysis of the experimental results is in progress. During the second test, a late event was recorded, which could be interpreted as a deferred failure of the test rod; the analysis of signals and their examination, which will be performed in the laboratory, will be used to confirm or invalidate this failure and, as appropriate, determine its characteristics.

Exemplary international co-operation

The technical and financial partnership of the CABRI-Water loop programme implies significant participation on the part of EDF and contributions from foreign partners, who have taken part in the programme under the auspices of the OECD (Organisation for Economic Co-operation and Development). To date, 10 countries (safety and industrial organisations) have signed a participation agreement with IRSN.

CABRI RESEARCH REACTOR

The CABRI research reactor is a unique installation in the world, used to simulate the conditions of a reactivity accident in a PWR. Operational since 1978, it was initially intended to safety studies of fast neutron reactors (with a loop cooled by liquid sodium). Four programmes were conducted on it, including the last one called CABRI-RAFT, carried out in partnership with the Japanese JNC organisation, ended in 2001. Its use for the CABRI-Water loop programme requires, on the one hand, an upgrading regarding safety given the evolution of the practices, especially regarding fire protection risks and seismic risks and, on the other hand, the replacement of the sodium loop by a water loop.

View of the CABRI pool and core (CEA facility).

> Safety review of nuclear power plants

The purpose of the safety review is to check, every ten years, the safety level of nuclear facilities, taking into account evolutions in safety practices (resistance to earthquakes...). 2002 was a pivotal year, with the end of the safety review linked to the second decennial outage programmes and the beginning of the safety review for the third decennial outage programmes of 900 MWe power plants. As for the 1,300 MWe power plants, the safety review began in 1997 for the second decennial outage programmes scheduled from 2005 on.

In practice, the safety review process for 900 MWe and 1,300 MWe power plants is based on two main parts: the check of the reactor's conformity regarding its initial safety baseline and the review of safety requirements. The studies initiated from the new safety requirements may lead to the implementation of modifications intended to improve safety during the next ten-yearly outages.

Safety review of the 900 MWe nuclear power plants for the second ten-yearly outages

The 900 MWe power plants using pressurized water reactors (PWR) are the oldest of the French nuclear power plants. They were put in service between 1977 and 1987. The safety review approach of these power plants has been initiated from 1987 for the oldest of these. This approach for all 900 MWe power plants will be completed as second ten-yearly outages of these plants go along, i.e. after 20 years of production.

130

IRSN monitors 130 basic nuclear installations (pressurized water reactors, fuel cycle plants...) in France.

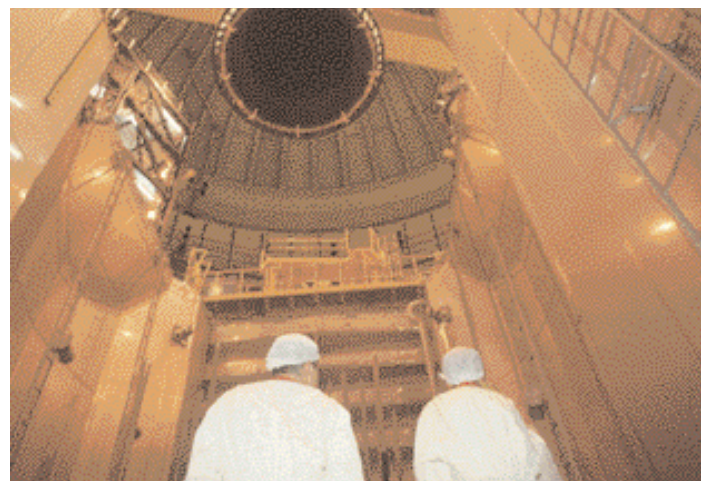
The French Standing group of Experts for nuclear reactors was regularly consulted throughout the various steps of the process which took place over more than 10 years.

In order to close this approach on all the 900 MWe power plants, the DGSNR (Nuclear safety Authority) requested the technical notices of the French Standing group of Experts related to the consideration of the safety requirements resulting from the safety review of the power plants after their second ten-yearly outage.

IRSN established an overall assessment of the approach conducted by the licensee and submitted its conclusions to the French Standing group of Experts on February 28th and March 14th, 2002. At this level, it did not discuss elements which could raise the question concerning the continuation of the 900 MWe plant operations until the third ten-yearly outages which will occur 2008 to 2015. However, EDF still has a significant amount of work to carry out to finalise this study. In fact, the compliance projects initiated and the modifications planned will completely help to improve the safety level of these power plants only at the date of their second ten-yearly outages.

Third ten-yearly outage programmes

The safety review associated with the second ten-yearly outage programmes has been particularly long. Thus, IRSN highlighted the need to rapidly identify the content of the phases of the safety review linked to the third ten-yearly outages: content definition of the safety review and associated baseline, actual studies, controls and implementation of the modifications. Furthermore, this process will be properly developed to meet the study deadlines of the modifications in order to implement them during ten-yearly outages. As the third ten-yearly outages of 900 MWe power plants are scheduled from the end of 2008, the definition of this safety review was launched as of 2002. This step is the first of a process which will set, by 2007, the requirements in which the 900 MWe power plants will be authorised to be still be operated after 30 years in service.



Reactor building (EDF installation).

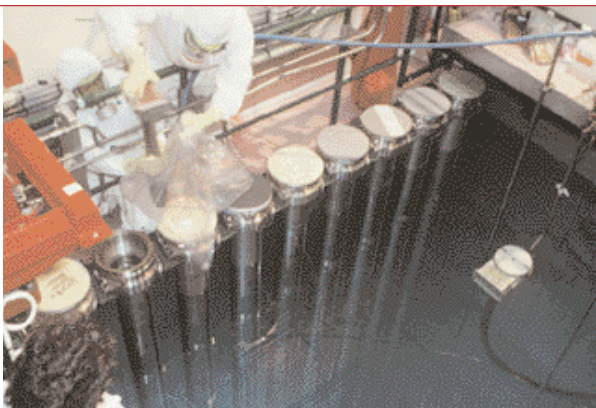
Safety review of 1,300 MWe nuclear power plants

On March 28th, April 4th and December 19th, 2002, IRSN submitted to the French Standing group of Experts for nuclear reactors its assessment of the safety requirement baseline and the EDF approaches concerning the compliance and reassessment studies for the 1,300 MWe power plants.

It emerged that there is a need for EDF to specify some points, such as the functional capacity of certain materials used in accidental situations out of postulated and takes into account new requirements resulting from the classification of the materials and systems required for safety.

Furthermore, the resistance to earthquakes of the buildings and equipment will be reassessed, taking into account the evolution of technical rules related to seismic risk, and the risks of explosion inside buildings shall be subjected to a safety review for all the power plants.

The next step will consist in assessing the detailed programme of the modifications and the results from the compliance examination of the reactors implemented by the licensee.



Storage pool of the PHEBUS test reactor (CEA facility).



Nuclear power station producing electricity in Saint-Laurent-des-Eaux.

REMOVAL OF THE RESIDUAL POWER FROM THE USED FUEL ASSEMBLIES STORED IN THE SPENT FUEL POOLS OF THE PWR (PRESSURIZED WATER REACTOR)

To reduce the shutdown periods of the reactors in order to increase their availability, EDF reduced the time between reactor shutdown and the end of fuel unloading. This leads to an increase in the residual power which shall be removed from the spent fuel pool during refuelling shutdown.

Therefore, the facilities participating in the safety of the irradiated assembly storage have been operated today beyond the conditions defined in the safety reports. This situation has been highlighted by the feedback of experience and the safety review performed for the 900 MWe power plants. It is processed through the implementation of transitory operation stresses to which final improvements are added. Within this framework, IRSN analysed EDF proposals in order to improve the safety of spent fuel storage and remove the current stresses involved in the operation of spent fuel pools of 900 MWe power plants.

The Institute analysed the material and documentary modifications proposed by EDF in order to strengthen the prevention, detection and management of accidental situations which could have an impact on the safety of irradiated fuel storage. It particularly studied if the proposed measures would make it possible to manage a complete and prolonged loss of coolant of a spent fuel pool and analysed the probability assessment transmitted by EDF related to the risk of fuel dewatering in such a situation. IRSN conclusions were submitted to the French Standing group of Experts for nuclear reactors in November 2002. It has been shown that the control of the cooling of spent fuel stored in the spent fuel pools of the power plants will be significantly improved when the modifications planned by EDF will have been applied. These modifications shall be adapted to be implemented on the most recent power plants (1,300 and 1,450 MWe).

> Research on the PWR core meltdown accidents

Although extremely unlikely, core meltdown accidents situations which have not yet been taken into account during initial design of the existing power plants deserve specific precautions. Significant research has been conducted by the Institute on the phenomena concerned, in order to contribute to the prevention and the mitigation of the consequences of such accidents. Today, IRSN is a major actor in research around the world on the accident situations of PWR core meltdown.

The core meltdown accidents would result from a series of failures and could generate significant releases of radioactive products in the environment.

Studies and research

The studies and research conducted at the Institute on severe accidents aim at:

- Identifying the possible accident scenarios and assessing their probabilities;
- Studying the progress and possible consequences of such accidents, including the risks of containment failure and the possible radioactive releases.

To achieve this, IRSN develops a research strategy which combines analytical experiments, the physical modelling of the phenomena, the development and qualification of software to be applied to reactors and the performance of global experiments, notably in test reactors. Research particularly studies core degradation, iodine chemistry, aerosol behaviour and containment resistance. They are subject to international collaboration, in particular with the European Union, the United States, Japan, Switzerland and Russia...



FP caisson whose loop (in red) simulates a steam generator.

A role to support public authorities

The task of the Institute is to bring technical elements enabling the public authorities:

- To assess the measures suggested by the licensees to prevent core meltdown accidents and limit their consequences;
- To assess retained or possible means to limit the consequences of such accidents;
- To prepare emergency plans and assess in real time, in case of accident, the risks encountered in order to be in a position to take countermeasures to be implemented for ensuring the protection of populations;
- To improve crisis management with a better assessment of the effects, measures and interventions provided for and periods of dreaded events;
- To assess the acceptability of the design of possible future reactors.

PROBABILISTIC SAFETY ANALYSES (PSA)

Published in 1990, the probabilistic safety analysis, called "level 1", assessed the probability of a core meltdown in a 900 MWe pressurized water reactor. It was prolonged with a "level 2" PSA whose objective is to assess the probabilities and levels of the releases in the environment resulting from accidental series of core meltdown. A first version of PSA 2 published in 2000 was based on a certain number of simplifying hypotheses, especially on the main question of the mechanical behaviour of containment. A modelling work for this containment, including the behaviour of the concrete, the liner and the singular areas, was used to remove in 2002 the simplifying hypotheses introduced. The result of this work will be integrated in the revised version of this study, whose development is in progress. These studies use all the experimental knowledge and the calculation tools available at the Institute. They are also used to highlight points where research still seems necessary.

International relations involve the SARNET network.



Phébus FP is the most significant research programme in the world regarding nuclear safety.

Operational since 1978 in the Cadarache (Bouches-du-Rhône) research centre, Phébus is an experimental reactor of the CEA, which was modified in 1989 to carry out the Phébus FP programme. The Phébus FP experimental facility is a 1/5000 simulator of the main components of a pressurized water reactor. It is used to perform global experiments reproducing all the phenomena occurring during a core meltdown accident and contributing to the release of radioactive products. The Phébus FP programme is an international programme conducted by IRSN and mobilising 35 organisations from the European Union, the United States, Canada, Japan, South Korea and Switzerland. In 2002, the participation in this programme of several organisations from candidate countries to join the European Union, was negotiated: Czech Republic, Slovakia, Hungary, Slovenia, Bulgaria and Romania.

The Phébus FP programme includes five tests spread over about 15 years. The first was performed in 1993 and three other tests were also performed, respectively, in 1996, 1999 and 2000.

After the analysis of the fourth test data, a preliminary synthesis of the Phébus FP programme, as a whole, was developed in 2002.

Three main points have emerged:

- Computer codes had to be modified. This concerns the chemical forms of fission products in the primary cooling system, the presence of gaseous iodine among the fission products released into the containment through the break in the primary cooling system, the production of organic iodine in the containment. These phenomena must be subjected to additional experimental work;
- Some unexplored phenomena appear significant: this concerns the degradation and re-localization of the fuel, the effect of fuel degradation on the releases of fission products, the transport of representative fission products in the primary cooling system, the iodine chemistry in the containment when materials from the control rods are present;
- Modelling concerning the thermohydraulic and the aerosol behaviour in the containment, the release and transport of the fission products are acceptable.

Furthermore, the preparation of the fifth test, planned for 2004, gave rise in 2002 to the end of the preliminary calculation phase, in collaboration with the German, Swiss and Japanese partners of the programme. Concurrently, major clean-up work was conducted in the experimental facility, before the installation of the new experimental circuits.

Lastly, an international exercise coordinated by IRSN was conducted under the auspices of the OECD (Organisation for Economic Co-operation and Development). The purpose was to test the performances of various software systems using the second test results. This project brings together over 30 bodies, located in 20 countries, to test 15 types of software. In 2002, new partners took part in the programme such as Mexico, Turkey and Croatia. They participated in the specification of the calculations to be performed and in the analysis, which will be completed in 2003.

ASTEC, an integrated calculation tool

Developed for more than ten years with GRS (Gesellschaft für Anlagen und Reaktorsicherheit – Germany), ASTEC is an integrated software system. It is used to simulate a core meltdown accident in a water reactor, from the initiating event to the possible releases of fission products out of the containment. ASTEC is currently used within the framework of Probabilistic Safety Assessments performed by IRSN. It is also used for the definition of the Phébus FP experiments. Today, ASTEC is becoming the European reference for integrated system software in its area.

The main efforts carried out in 2002 focused on the V1 version, delivered during the middle of the year. This will now be strengthened, in particular within the framework of EVITA, the European ASTEC qualification project. Furthermore, new models were developed, concerning iodine in particular.

Lastly, the training of software users started in 2002 and involved concerned 40 people from all European countries.

SARNET, creation of a network of excellence on core meltdown accidents

Conducted by IRSN, SARNET is a project which will be submitted to the first call for tender of the 6th Framework Programme. The purpose of this network is to better coordinate the research efforts of European laboratories dealing with core meltdown accidents. For IRSN, this is the following step forward in international collaboration already conducted in this area.

This is also an opportunity to support the ASTEC software system at the European level, in order to improve its reliability, with the feedback of experiences by European users.

Already, almost 370 researchers and doctorate students from 52 European organisations have expressed interest in taking part in the network.

> Ensuring waste management safety

The purpose of radioactive waste management is to confine radioactivity to result in the lowest risk possible level of risk for human beings and the environment. To assess the measures proposed by licensees, IRSN will be able to evaluate their completeness and their quality, in normal or accidental situations, for the disposal and of various waste management options. Thus, the Institute has been carrying out research programmes to acquire appropriate knowledge in the concerned fields.

Medium and long-term issues

IRSN studies focus in particular on:

- The safety of radioactive waste treatment, conditioning, interim storage and surface disposal facilities;
- The disposal possibilities in deep geological formations. For this purpose, IRSN develops both field experiments and modelling;
- The studies of the impact on human beings and the environment of contaminated sites by former industrial activities and mining sites.

Evaluation of the feasibility of a deep geological disposal

Concerning the disposal of the high level and long-lived radioactive wastes in geological formation, the law of December 30th, 1991, scheduled the presentation of a progress report on research for 2006. In order to prepare a possible decision on the feasibility of deep disposal, the Institute has identified "key points" for the safety assessment of a disposal in the clay unit of the Meuse/Haute-Marne site studied by ANDRA (National Agency for Radioactive Waste Management).

Those key points highlight three types of concerns:

- The general knowledge of the site: structural geology (identification of the secondary fracturing); hydrogeology (outlets and transfer times); chemical and thermal containment capacity of the clay unit;
- The feasibility of the design options of a disposal: assessment of the chemical disturbances; disposal layout and damaging minimization; sealing and restoring the environment continuity;
- The operation and reversibility conditions of the disposal.

In 2002, IRSN evaluated the geological and hydrogeological modelling presented by ANDRA for the Meuse/Haute-Marne site. Within this framework, IRSN took into account the first results of geophysical experiments carried out in the underground research laboratory at Tournemire using a high resolution 3D seismic method to assess the capacity of the method to detect secondary faults in argillaceous media.

Application of the high resolution 3D seismic method to detect faults in argillaceous media

In a very low permeability clay unit, the transport of radionuclides preferentially occurs along faults. Therefore, the assessment of the capacity of a clay unit to host deep disposal implies the detection and mapping of the existing faults.

The high resolution 3D seismic method is a tool aiming at detecting faults. A seismic survey coordinated by IRSN was carried out at the Tournemire site (Aveyron).

The principle of the method is the following: vibrator trucks shake the ground to frequencies ranging from 10 to 160 Hz. The 3D propagation of the seismic waves are reflected by the geological discontinuities. A network of 5,600 sensors set on the surface and connected to an acquisition unit enables information to be collect, like a sonogram.

The main faults can be identified by classical geophysical methods. On the contrary, the secondary faults mapped at the Tournemire site cannot be identified by classical geophysical seismic methods (2D).

After preliminary studies, the survey took place over 3 weeks in November 2001. It mobilized almost 20 people.



Geophone used for seismic recording.

According to the first results published in 2002, the analysis of the data did not allow the identification of the faults in the clay unit. This preliminary result does not mean that the principle of the method is not appropriate. In fact, progress is expected in the future, which will enable a better resolution.

Mining waste management

Waste from uranium mines contains radioactive residues stored on site. Their concentration in radionuclides classifies it in the category of low radioactive waste, but its volume, its physical and chemical form and the lifetime of the radioelements contained (a period of several thousand years) nevertheless generate questions regarding public protection.

To begin with, IRSN has to express its opinion on the protection means implemented by the licensee after the decommissioning of the mine. Thus, the study of the file dealing with the radiobiological impact assessment after the redevelopment of the last site operated, Jouac, is currently in progress.

More generally, the expertise showed that mining activity is at the origin of a measurable radiological marking of the environment. In order to have more complete information, IRSN launched a programme of investigations in 2002 upon the request of the Ministry of Ecology and Sustainable Development. The purpose of this programme is to assess available knowledge concerning all the sites in order to identify the situations of significant marking or lack of information. Then, if appropriate, it can be used to complete the knowledge on the radiological status in the less studied mining regions and possibly to suggest inflections to the existing measures.

Chernobyl experimental platform

In the area called the "Red Forest", located a few kilometres from the Chernobyl power plant, soils and debris contaminated by the accident were buried in rapidly dug non-waterproof trenches. Subject to the action of the rain waters, these trenches release radionuclides in the natural environment.

In 1999, IRSN initiated co-operation with Ukrainian organisations (IGS and UIAR) and the CEA (Atomic Energy Commission), in order to study the transport of radionuclides in the environment. The knowledge acquired within the framework of this research greatly interested the concerned countries. For the Ukrainians, this may be applied to rehabilitation of the site. For the French, this is being used as a full-scale validation of models used for the storage of radioactive waste or the rehabilitation of contaminated sites.

An experimental platform was implemented comprising equipment used to monitor the contamination. From this platform, the researchers study three different environments contaminated in various ways:

- The location of the former trench, the most contaminated environment;
- The unsaturated zone which extends to the surface reaching 3.5 m in depth, and in which cracks are not completely filled with water;
- The aquiferous formation below 3.5 m, where water fills in the vacuums left by solid material.

Relevant results were obtained, especially in the trench and in the aquiferous zone. This work, summarised in 2002, was used to identify the particles which mainly contribute to the radioactivity source, characterise their respective dispersions and compare these observations to the modelling. For the unsaturated zone, the forecast of the long-term migration of the radionuclides will require the exploration of other phenomena by specific programmes.



Redevelopment of the mining site of COGEMA Lodeve.



Chernobyl experimental platform: installation of water sampling probes.

> Expertise used for industrial risk control

All the research and expertise work conducted in the Institute provide it with competencies which find applications beyond nuclear power, in particular in the area of industrial risk.

Expertise of classified facilities

As an expert recognized by the Ministry of the Environment, IRSN conducts critical analyses of danger studies performed by industrialists. To do so, it calls upon its competencies, in particular in chemistry, chemical engineering, fire protection and explosion. In 2002, the Institute conducted almost 40 critical analyses of danger studies concerning facilities classified for the protection of the environment. The tripling of critical analyses, compared to 2001, is mainly a consequence of the accident of the AZF plant in Toulouse (Haute-Garonne). The expertise performed

40
In 2002, IRSN performed 40 expertise studies concerning non nuclear industrial facilities.

in 2002 concerned various plants: petrochemistry, transformation chemistry, fine chemistry, agricultural and food system, agro-pharmaceuticals, etc. These focused on a very wide range of topics: risks of fire, explosion, thermal runaway, toxic gas dispersion, environmental impact. IRSN also performed less common expertises such as the processing of exemption claims for the implementation of safety valves on pressurized equipment or the determination of domino effects on some industrial sites.

Expertises in olfactometry

For over 30 years, olfactometry has used and improved the knowledge and competencies acquired in the nuclear sector on gas transfer and dispersion. Today, IRSN conducts expert activity for industries producing malodorous gas releases. The results of the olfactometric measurements performed by the Institute are used to

orientate the choice of technological solutions intended to limit the impact of the olfactory pollution of industries on the environment. IRSN works on this issue in collaboration with INERIS (National Institute of the Industrial Environment and Hazards).

In 2002, 15 studies were conducted for industrial facilities (agricultural-food system, rendering and transformation plants, technical land fill centres), research departments, local communities (contaminated site services, treatment plants) and breeding (pigs, poultry).

The Institute also takes part in training on the subject from professionals working in air quality networks and treatment plants, DRIRE (Regional Agency for Industry, Research and the Environment) and DSV (Veterinary Services Branch) members or within the framework of DESS and DUT on the environment...



Panelist sniffing the olfactometer sniffing ports.

Physics of aerosols

Physics and metrology of aerosols find applications outside the nuclear area. In addition, since it is little developed in France, the competencies acquired and maintained within IRSN are today recognized all over the world.

Within this framework, the Institute is represented in the scientific committee of the national safety research

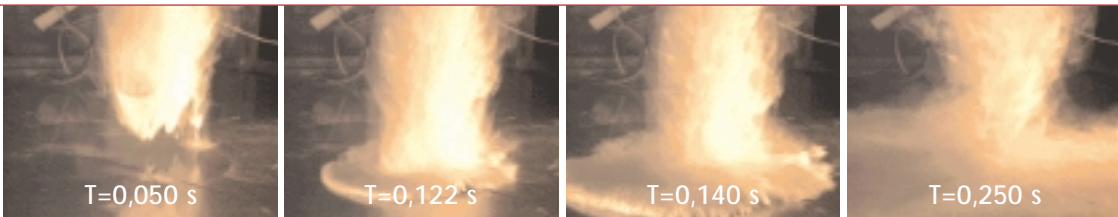


LPG reception in the Herrlisheim site.



Canalised sampling of an odorous gas sample.

Air contamination experience: suspension during an accidental powder drop.



institute, which conducts work on professional risks. It takes part in the work of the contamination prevention and study association, bringing together agricultural-food, medical and other industries.

In the area of professional risks, IRSN participated in a European commission contract for the improvement of the performance of aerosol samplers at the workplace (CALTOOL). The purpose was to test those sampling tools to compare their efficiency in different situations and different workplaces. The contract ended in 2002 and was related in publications.

Besides, many nuclear-related activities may have wider applications, in particular for toxic powders. A common interest programme is in progress with COGEMA on the suspension of powders during drops of the containers.

Lastly, the international recognition of its competencies was expressed by the granting of the "International aerosol fellow Award" in 2002 to a researcher of the Institute.

Probabilistic assessment in a storage and filling centre for liquefied petroleum gas

Upon the request of the Ministry of the Environment, IRSN took on the responsibility for conducting a Probabilistic Safety Assessment applied to a SEVESO-type facility. The objective of this assessment is to better understand the additional knowledge that a probabilistic assessment could provide for the safety of these facilities.

In collaboration with the French butane and propane committee, the site choice was made on a storage and filling centre of liquefied petroleum gas, managed by the Rhône-Gaz company in Herrlisheim (Bas-Rhin).

The assessment was carried out in two stages:

- The definition of a study method appropriate to the facility, in collaboration with the industrialist concerned;
- The performance of the assessment per se.

The assessment consisted in identifying the various accidental series which may lead to a BLEVE (Boiling Liquid Expanding Vapour Explosion) in case of the heating of one of the storage capacities, inducing a fire ball, a shock wave and projections, and assessing the probabilities of these series. The initiating events of the accidental series may be process failures but also internal hazards (fire, flooding...).

In 2002, the first phase of the project was carried out and presented to the Ministry. The development of qualitative event trees highlighted safety elements which significantly contribute to the series of undesirable events leading to the BLEVE on the one hand, and some difficulties to quantify the accidental series, due to the limited representative nature of some models and the use of generic data, on the other hand.

The assessment involves up to 15 persons in the Institute, with various competencies: safety, development of Probabilistic Safety Assessments, accident phenomenology, assessment of weather variations or hazards related to human activities in the site environment...

The assessment and conclusions should be submitted in May 2004.

WORK CONDUCTED WITH INERIS

The collaboration between IRSN and INERIS originates from the will of both organisations to develop their synergies.

In the area of olfactometry, the collaboration between both organisations concerns:

- Expertise combining IRSN competencies for olfactometry and INERIS competencies for physical chemistry. Two assessments were conducted in common in 2002;
- The draft of an "odours" guide, upon the request of the ADEME (Agency for the Environment and Energy Control) and in collaboration with other experts. This guide will introduce all the approaches that an industrialist shall adopt to limit the olfactory pollution resulting from his activities;
- The implementation of a reflection group on the regulation, measuring techniques and future European standard as regards olfactometry in late 2002.

Concerning fire risks, collaboration focuses on research projects. In 2002, the work was particularly focused on the characterisation of the fire power of various fuels.

Lastly, collaboration regarding ecotoxicology particularly focuses on research concerning the toxic effects of uranium on the fish and the development of genotoxicity markers.

> Controlling criticality risk

IRSN deals with various aspects of criticality risk, from prevention to the assessment of consequences. The purpose is above all to prevent the development of a chain fission reaction out of a nuclear reactor, i.e. in a facility not intended for that purpose (plant, laboratory or transport packing). This type of reaction involves the release of neutron and gamma radiation as well as the production of radioactive products likely to be spread out of the concerned facility. The main consequences of a criticality accident would therefore be to irradiate persons who might be close to the accident site. The Institute develops qualified computer methods and applies them to the assessment of the measures used to prevent criticality risk and, in case of accident, it assesses the consequences on health and the environment.

Technical and economical issues

Prevention of criticality risk was a major concern beginning with the very first uses of nuclear power. It led to the implementation of restricting measures: limitation of the product quantities, container size, water quantities used, etc.

Progress of knowledge today enables some stresses to be reduced, while ensuring the safety of the facility or transport packing. In this area, IRSN prepares methods, develops software and conducts case studies. The objective of this work is to have accurate means to analyze the criticality risk.

The qualification and validation of computer tools focus on comparing calculation results based on reality and experiences approaching critical status. The comparison of the calculated results and experimental results is used to establish the accuracy of calculations for specific situations, and, if appropriate, suggest improvements of the calculation techniques.

Beyond research, IRSN also provides expertise, in particular for laboratories, plants and transport. The work in analysis involves checking that prevention measures, suggested by the licensee on the basis of calculations, are appropriate and sufficient, including cases of possible malfunctions. For the transport of fissile materials, the verification of criticality calculations of carriers is systematic. In the case of assessments carried out with

third-party software, counter-calculations are conducted. Every year, over 50 files concerning the transport of fissile materials, each corresponding to multiple contents, are studied in the Institute.

CRISTAL, a new generation criticality-safety package

CRISTAL is a programme conducted by IRSN, developed with the CEA and financed by COGEMA.

Since 1999, the first version of this software has been made available to IRSN, the CEA and major French nuclear industrialists (COGEMA, Framatome, Technicatome). It is used by 90 engineers and is currently being tested by EDF. Within the framework of this programme, IRSN develops the 3D multi-group neutron simulation code, Moret IV. Furthermore, it is equipped with the man-machine interface which ensures the integration of various calculation modules, as well as the connection with users, which is used to take into account their experience.

In 2002, a CRISTAL Web site was opened to the public at large; there is also a Web site restricted to users so they can share information, remarks and inquiries. Users can also download documents or correction patches. In addition to the development of a user community promoting the exchange and the availability of information, the openness of the site was intended to implement a working organisation with users, especially for maintenance.

It was updated for the first time in September 2002. The development of the next version has been initiated. It will include new functionalities and is slated to be delivered in September 2003.

Lastly, IRSN participates in the International Criticality Safety Benchmark Evaluation Project, under the auspices of the OECD. This project consists in pooling criticality experiences which have been conducted around the world for over 20 years. This work is essential for the qualification of calculation systems such as CRISTAL since in fact, almost 1,200 criticality experiences from various sources were recalculated by CRISTAL.

A common interest programme with COGEMA

In 2002, experimental programmes were carried out within the framework of the Common Interest Programme initiated with COGEMA as of 1996. This programme concerns the prevention from criticality risks in fuel cycle installations and transport.

The purpose is to quantitatively assess the safety margins related to the loss of reactivity of irradiated fuels, and to develop more accurate calculation methods intended to assess criticality risks. For those fuels, experiences have been conducted for six stable fission products causing half of the reactivity loss generated by the fission products.

In addition, this programme aims at improving the criticality calculation systems to meet new needs for nuclear facilities and the transport packing for fissile materials. The experiments conducted on the Valduc (Côte-d'Or) site are unique in the world.

An exercise to compare the dosimetry methods for criticality accidents

In 2002, IRSN organised an international intercomparison exercise of dosimetry for criticality accidents. This operation, jointly conducted with the OECD Nuclear Energy Agency, was performed in collaboration with the Valduc CEA centre. It was supported by the European Commission.

Almost thirty countries from Eastern and Western Europe, North and South America, as well as Asia, participated in this exercise.

It enabled each of them to test the physical and/or biological dosimetry techniques in experimental conditions simulating a criticality accident.

This intercomparison had been scheduled just before the criticality accident which occurred in September 1999 in Tokai-Mura (Japan).

It involved experiences conducted in the Valduc CEA centre on the Silène reactor, simulating different criticality accident configurations generating an intense release of neutron and gamma radiation.

The results of the final assessment and the conclusions will be published within the framework of the "9th International Symposium on Neutron Dosimetry" in Delft (Netherlands) in September 2003. A complete session will be dedicated to this intercomparison.

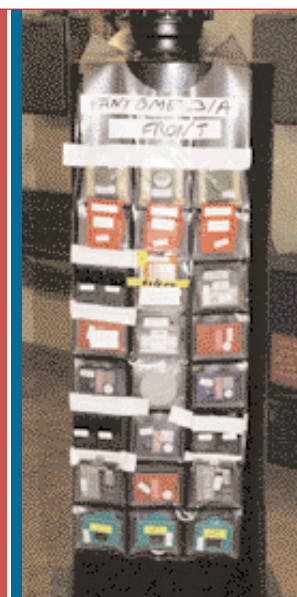
29
different countries

60
laboratories

500
irradiated dosimeters
for the international
intercomparison of
accident dosimetry
organised by IRSN
in 2002.



Criticality dosimeters exposed around the Silène reactor.



International intercomparison of dosimetry on the Silène reactor: positioning of dosimeters.

> Assessing transport safety

The use of some package types to transport of nuclear materials is subject to an agreement issued by the competent authority: DGSNR for civil use transports, DSND for the transport of materials for Defence purposes. IRSN performs studies and research as well as expertise on the transport of nuclear materials.

Expertise of transport packages

Every year, the Institute transmits between 100 and 150 technical notices on the compliance of transport packages of nuclear materials according to regulations. In these technical notices, several aspects are considered:

- The safety of the radioactive material containment;
- Radiation protection of workers and of the public;
- Prevention from criticality risks.

The certifications of new packages are issued for a period of three to five years. In the case of a certification extension, the Institute performs partial expertise only, with particular emphasis on the examination of acquired experience. For some types of packages, the expertise especially focuses on the radiolysis risk.

Radiolysis during the transport of nuclear materials

The phenomenon of radiolysis (decomposition of water into hydrogen and oxygen by ionising radiation) may have an impact on the safety of the transport packages, as it may lead to an explosion. For this particular issue, the Institute has conducted a review of the package models approved or under special agreement for 10 years.

Given the diversity of the situations encountered and the complexity of the radiolysis phenomenon, industrialists have been requested to base their justifications on experimental values. Industrialists performed measurements in real conditions, in order to quantify the radiolysis phenomenon for all packages. For this purpose, they developed experimental programmes, including some now which are nearing completion.

The packages concerned are divided into several categories:

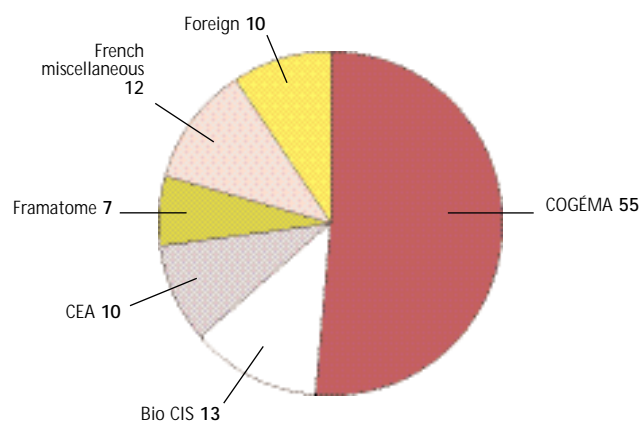
- Those used for under-water transport of irradiated fuels intended for reprocessing: CASTOR S1, EXCELLOX 6, NTL 11, NTL 15. These packages have been equipped with new catalysts (recombining hydrogen and oxygen) used to remove the gas released by the water radiolysis. The assessment of this equipment is in progress;
- Those used for the transport of organic waste (cellulose, various plastics, gloves...): TN GEMINI, RD 26, RD 15IIB, IU 11, DGD-D-001. Given the difficulty to conduct ana-

lytical experiences, it was decided to proceed on a case by case basis and to conduct campaigns for measuring the hydrogen concentration depending on weather and the activity of the waste transported. This was used to quantify the phenomena and to show that the hydrogen concentrations do not reach safety limits;

- Those used for the transport of plutonium oxide (FS 47, TN BGC-1), for which oxygen absorption, and not hydrogen production, appears.

The safety approach related to the radiolysis risk is a gradual and cautious approach which first consists in issuing transport authorisations for power ranges and limited durations, and then extending these authorisations depending on the results of the experimental programmes.

DISTRIBUTIONS OF THE 111 TECHNICAL NOTICES RELATED TO THE PACKAGES TRANSMITTED IN 2002



USING FEEDBACK FROM EXPERIENCE

IRSN analyses the incidents and accidents of transport of nuclear materials. Thus, the analysis of the incident occurred on December 29th, 2001 at Charles-de-Gaulle Roissy (Val-d'Oise), during a transport of radioactive products from Sweden to the United States led to the following conclusions:

- The quality of the package preparation shall be rigorously controlled;
- The packaging of the package content will be better specified;
- The radiation protection programmes, compulsory since July 2001 for air transports and dosimetric monitoring of the most exposed workers, will be rapidly implemented by the carriers.

End of the Common interest programme with COGEMA on the safety of the transport of nuclear materials

Started in 1996, the Common interest programme ended in 2002 with the completion of a study on the thermal behaviour of the transport packages TN 12/2 and TN 28 VT, subject to fires of variable duration.

According to the regulation, a type-B package shall resist a 800° C fire during 30 minutes, in order to be authorised. The purpose of this study was to determine the realistic durations of fire resistance of the packages for different temperature levels.

A calculation approach was used to realistically describe the behaviour of some package materials such as resin. The study used three-dimensional models appropriate to the simulation of the phenomena and especially to identify the presence of discontinuities in the packages.

The code developed was qualified using the experimental results obtained on a real package and on samples subject to tests in an oven. The simulation was used to determine the maximum durations of fire resistance of these packages by studying the risks of loss of seal tightness, clad failures and deformation of the internal structure of the package.

Four temperatures were studied: 400° C, 600° C, 800° C, 1,000° C. Temperatures below 800° C concern mainly maritime transport. The 1,000° C temperature is associated with tunnel-type configurations or special hydrocarbons (kerosene type).

A NEW COLLABORATION CONCERNING RADIATION PROTECTION IN TRANSPORTS

Dosimetric data of the SISERI database have been used as part of a European study on the statistics of transport flows and doses, conducted in 2002 and intended to better understand the impact of transport on workers' dosimetry.

The calculations related to both packages take into account the temperature increase inside the package after the end of the fire. For example, the containment of the TN 12/2 and TN 28 VT packages is ensured for an 800° C fire lasting over 1 h 40, which highlights a safety margin of about three times the regulatory duration of 30 minutes.

This study confirmed the significance to use three-dimensional models despite the complexity of their implementation.

Within the framework of this programme, IRSN developed a very sophisticated tool intended to assess the temperatures of the packages in various fire conditions: THERMX-PROTÉE, now available for applications to other packages.



A ship for the transport of spent fuel packages (TN12/2).



Return of vitrified residue to Japan in TN28VT transport packages.

> Reinforcing fire protection

The risk of fire is a major safety concern, given the probability of a fire in a nuclear facility and the severe consequences that a non controlled fire might cause. The research, studies and expertise conducted by IRSN on fires allow better assessment of the measures taken by the licensees to ensure the safety of their facilities and promote improvements.

A close connection between expertise and research

The assessment of the technical measures taken by the licensees to ensure the safety of their facilities against fire risks revealed the existence of insufficiently known areas requiring research actions. These actions include experimental programmes and modelling work and the results of this research contribute to improve the safety measures implemented.

Studies underlying areas of uncertainty

The studies conducted to support safety assessment focus on all the mechanisms which can generate releases of radioactive products following a fire. Among these studies, the Probabilistic Safety Assessment conducted on the risks of core meltdown in case of fire in a 900 MWe power plant particularly highlighted significant uncertainty areas that led IRSN to perform research to improve knowledge. This was the case for the following topics:

- The combustion of electrical boxes: the CARMELA programme provided in 2002 first results related to this subject;
- The propagation to adjoining premises via ventilation and the openings of a fire started in a close and ventilated room with the DIVA programme being initiated;
- The behaviour of compartmentalisation and containment equipment (doors, fire-dampers, filters...) submitted to stresses resulting from a fire: the STARMANIA programme, started in 2001 and continued in 2002, studies this subject;
- The “characterisation” of fuels: the action conducted by IRSN aims at improving the existing database by measuring certain physical properties of almost thirty materials.

The first lessons drawn from these research programmes have already been used for expertise purposes, in particular for the assessment of the vulnerability of the control rooms of nuclear power plants. Improvements have been recommended following this assessment.

Furthermore, the examination of the operational experience highlighted other concerns, such as the soot corrosion aspect and the evolution of the concrete tightness submitted to a thermal flux. Those topics are subject to thorough thinking in order to define, if appropriate, future research programmes.

Most of the topics cited above and the results of the corresponding research also demonstrate an interest for the safety of the laboratories and plants. For these types of facilities, work was initiated in 1998 in order to revise the Fundamental safety regulation I.4.A, related to fire protection of basic nuclear installations other than nuclear reactors. The objective is to take into account the progress of knowledge and to better distinguish problems in the fire area (compartmentalisation of the premises) and problems in the containment of radioactive materials. The new draft, discussed in November 2001 by the French Standing group of Experts, was deepened in 2002 and was subjected to application tests in a facility.

SAFETY ASSESSMENT

In 2002, the Institute studied the Fire action Plan implemented by EDF on its installations, and submitted its technical notices to the French Standing group of Experts for nuclear reactors on November 7th and 21st, 2002. These technical notices highlight:

- The needed evolution of the baselines, given the research conducted within IRSN;
- Improvement proposals for the CPY control room.

Test of the CARMELA programme for studying the combustion of electric cabinets.



Research to improve scientific knowledge

The propagation of a fire to adjoining premises via ventilation and/or the openings of a fire started in a close and ventilated room.

The DIVA facility was set up in 2002 to improve knowledge on the propagation of hot gas or particles to adjoining premises of a burning room, via the ventilation system and the other communicating channels (doors, openings, etc.). This facility houses three rooms leading into a common corridor. A fourth room is used to study the propagation to the upper stages. The premises are connected by doors, for which leakages may be calibrated, and by an industrial-type ventilation network. The first tests took place in 2002 and their interpretation is in progress.

The solvent fires in the storage cells of the COGEMA plant of La Hague (Manche).

The FLIP (Liquid fuel fires interacting with a wall) test programme was conducted between 1996 and 2002 in collaboration with COGEMA. It concerns the development of a pool solvent fire (hydrogenated tetrapropylene-tributyl phosphate or TPH/TBP) that might occur in a room dedicated to the storage of this solvent. In 2002, the focus was on the carrying out of the final tests and the interpretation of the tests performed during the previous years, as well as the qualification of the FLAMMES/SIMEVENT coupled code on the basis of those tests. A summary document was drafted following this instructive programme (for example, on the maximum levels and the temporal evolutions of the pressures and temperatures for different ventilation network operations).

The behaviour of compartmentalisation and containment equipment subject to a fire.

To better assess the behaviour of the compartmentalisation elements in case of fire, in particular their resistance to pressures which may result from these, a programme was conducted in 2002 in the STARMANIA facility concerning the aerodynamic behaviour of fire dampers and their degree of mechanical resistance. Furthermore, filter clogging, which may lead to a loss of containment of the radioactive substances, in particular by breaking the filter medium, was studied in the BANCO facility. All the tests performed on filters were used to develop an empirical model of aerodynamic resistance used in the modelling of the interaction between ventilation and fire.

Combustion mode of electrical boxes.

The first tests of the CARMELA programme, conducted in 2000 and 2001, were interpreted in 2002. A complementary experimental campaign, CARMELA Bis, was defined and prepared in 2002 to better characterise some physical parameters used by the model developed during the interpretation of the CARMELA tests. The programme will be completed in 2003 by the carrying out of combustion tests on real cabinets.

Suspension of radionuclides.

In case of fire involving radioelements, these can be released in the form of aerosols or gas. The determination of the suspension factors is essential to assess the releases of radioactive materials and the radiological consequences for workers and the fire fighters. Regarding this subject, IRSN completes and improves the BADIMIS database concerning the suspension of particulate contamination by different mechanisms.

Solvent pool fire test of the FLIP (Liquid fuel fire interacting with a wall) programme.



Starmania facility used to study the behaviour of containment and compartmentalisation equipment in case of fire.

IRSN

Ensuring non-proliferation and protection against = malevolent actions



Control of nuclear materials during transport.

62

In 2002, IRSN performed 62 analyses in the chemical area for the Senior Civil Servant for Defence of the Ministry of Economy, Finance and Industry.

50 inspections

100 reports

IRSN assesses measurements by operators to protect their facilities and nuclear matter contained in these. Within this framework, the Institute performed 50 inspections and transmitted 100 advisor reports to the Senior Civil Servant for Defence in 2002.

Non-proliferation of nuclear, chemical and biological weapons and protection against malevolent actions are two areas where IRSN conducts expertise work and research. Some of its agents are also authorised to conduct inspections. It reports in particular to the Senior Civil Servant for Defence of the Ministry of Economy, Finance and Industry.

IRSN makes its knowledge and practices available to the French authorities and international organisations involved in the implementation in France of treaties of non-proliferation of nuclear, chemical and biological weapons.

Protecting nuclear facilities and transport of nuclear materials against malevolent actions which may lead to radioactive releases in the environment is the aim of the struggle against malevolent actions which became an even greater concern after the terrorist attacks in September 2001.

> Non-proliferation of chemical weapons

IRSN lends its technical support to public authorities and to the industrialists for the implementation in France of the international controls in the non-proliferation area. Initially, only the nuclear sector was concerned. Given the experience acquired by the Institute in this area, the public authorities commissioned it to ensure the same mission for the application of the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (CWC), signed in Paris in January 1993. Lastly, since 1999, the Institute has also been involved in the area of the non-proliferation of biological weapons.

The Convention on the Banning of Chemical Weapons entered into force in France in 1997. Since this date, the Institute has provided expertise and undertaken technical support missions requiring scientific and legal competencies, focusing on three activities:

Technical support to the authorities for international negotiations and for the implementation in France of the Convention in the civil sector.

The Institute carried out the census of industrialists concerned by the Convention, who must declare the products they use. It analyses and processes their declarations.

Concerning the international relations, in 2002 IRSN participated in the expert group implemented by the Organisation for the Banning of Chemical Weapons, on the homogenization of the declarations. This resulted in November 2002 in defining rules and declaration thresholds for imports and exports of the chemical products concerned, common to all convention signatory countries. This will imply a change in the French regulatory texts, manuals and declaration forms. The related work was launched in 2002.

Advice to industrialists for preparing the declarations and international controls.

IRSN advises industrialists for preparing declarations, taking into account the characteristics of their facilities.

Preparatory visits before international inspections represent for IRSN educational work to the industrialists. The purpose is to make them aware of the provisions of the legislative and regulatory Convention texts and of the consequences for facilities: check of declarations, frequency of inspections, access of inspectors to "sensitive" areas and information for the economic development of the company. IRSN performs preliminary visits of the sites in order to facilitate the process of the inspections proper. In 2002, the Institute performed 18 preliminary visits.

Supporting the international inspections

Performed by the OPCW, the purpose of the inspections is to check the compliance of the information transmitted by the French authorities in the declarations. During these inspections, IRSN, as French state representative, plays a role of interface between inspectors and industrialists. The sites inspected are chosen by the OPCW from information provided in the declarations.

Until 2000, most of the inspections conducted in the world concerned the main industrialised countries. This represented 20 inspections for France. In April 2000, the inspection was extended to all organic chemical products, significantly increasing the number of countries involved. After facing some financial difficulties, the OPCW continued as before with the same sustained inspection pace as of the fourth quarter of 2002.

MONITORING OF TRANSPORT FOR SENSITIVE NUCLEAR MATERIALS

The Transport Operational Echelon (EOT) was created in 1983 within the Institute to assume operational responsibilities in the area of the management and monitoring of transport of nuclear materials.

Within this framework, every year it examines almost 2,000 transport authorisation requests and ensures the monitoring of these transports on the national territory.

This involves road, rail, sea or air transport (from or to a port or airport under French jurisdiction).

The monitoring of each transport is in keeping with the sensitivity of the materials transported. Some transports, among the most sensitive, follow routes authorised by the Senior Civil Servant for Defence of the Ministry of Economy, Finance and Industry and are monitored in real time by IRSN, with satellite communication means.

This monitoring allows any incident, accident or event to be detected which may delay or hinder the transport. In such cases, the EOT takes appropriate measures: information to authorities, initiation of emergency of physical protection actions, transport stop, route change, etc.

In addition to transport monitoring, the agents authorised by the EOT conduct unannounced transport inspections, in order to ensure the compliance of the regulatory provisions. Crossing conditions for highway tolls and borders, reception and parking conditions of convoys, locking and monitoring of vehicles during stopovers, etc. More than 40 inspections are conducted every year, in harbours, stations, borders and airports or near installations authorised to have nuclear materials.



Control of nuclear materials during transport.

> Protection against malevolent actions

One of the Institute's missions is to assess the measurements taken by the industrialists to protect their facilities and the transports of nuclear materials against possible malevolent actions which may cause releases of radioactive products in the environment. Of course, the results of those assessments remain highly confidential, but the terrorist attacks of September 2001 reinforced the concern of public authorities in this area.

Malevolent actions facilities

The assessment of the measures taken or provided for by the operators is performed by the Institute from predefined types of threats. The purpose is to ensure that these measures are sufficient and to recommend, if necessary, the implementation of complementary measures. The approach adopted comprises three stages:

- The assessment of the sensitivity of the various facilities and equipment. Sensitivity is characterised by the significance of the consequences which may result from a malevolent action, i.e. quantities of radioactive or chemical products which may be released in the environment;
- The assessment of the vulnerability of the equipment considered sensitive, i.e. the assessment of the difficulty to launch a given attack on this equipment;
- The research, if necessary, of complementary provisions used either to reduce the equipment sensitivity or to make a possible attack more difficult.

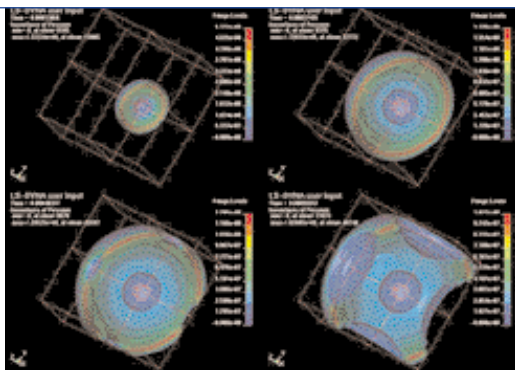
Several typical threats have been defined: their relevancy is subject to a comparison with the lessons drawn from events having occurred in France or abroad, possibly in

other industrial sectors outside the realm of nuclear activity. Those events are compiled in a record of malevolent actions, drawn up by the Institute. In 2002, suggestions were made by the Institute to harden the typical threats, in particular by taking into account the lessons drawn from the attacks of September 11th, 2001. Furthermore, IRSN also suggested to the authorities draft regulatory texts aiming at reinforcing and specifying the regulations.

In addition to those assessments, IRSN supports the inspections of nuclear facilities in the malevolent area.

In 2002, a particular effort was made to control access to facilities: implementation of complementary provisions and verification of this implementation on the sites (about thirty), as part of the Vigipirate anti-terrorist plan. These stiffer measures of the access of persons, vehicles and goods concerning EDF, the CEA, COGEMA, EURODIF (European uranium enrichment by gaseous diffusion plant) and ILL (Laue-Langevin institute).

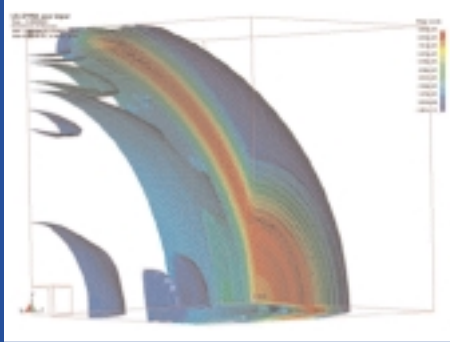
Lastly, the Institute conducted experiments and studies on the assessment of damages to buildings, storage ponds, and ventilation systems in case of malevolent actions.



Digital simulation of an explosive detonation.



Transport of casks of spent fuels.



Digital simulation of an explosive detonation.



Transport of packing and spent fuels.

Malevolent actions against transports of nuclear materials

IRSN conducted research, in particular concerning the resistance of packing to terrorist attacks. The purpose of this work is to have tools to assess the consequences of such attacks, to be able to suggest appropriate technical or regulatory developments. If the packing design resulting from the application of the safety regulation ensures a certain degree of defence and if various tests were performed in the past, the approach adopted today is more systematic with the use of digital simulation. It is intended to focus on the tests to be performed and to make better use of these.

Since 2000, IRSN has been developing a programme intended to study a representative assembly of packing subject to various types of weapons (firearms, high explosive charges, antitank weapons, etc.). The related work is jointly conducted with the DGA and the CEA.

In the area of explosive charges, 2002 saw the completion of tests for a first packing, with the validation of associated digital models.

Concerning perforating charges, a study was conducted in 2002 for this same transport packing and showed that the results from the digital simulation were consistent with the results from experiments.

Concurrently, collaboration was launched with the United States, the United Kingdom and Germany concerning the possible radiation consequences of an attack of a transport of irradiated fuels with a perforating charge.

STUDY OF IMPACT OF AN AIRCRAFT ON A POWER PLANT

Following the attacks of September 11th, 2001, IRSN performed a study on the mechanical behaviour of the containment of a nuclear power plant in 2002 modelling in detail an attacker using a commercial aircraft of currently in operation and considering different trajectories and speeds as well as different impact points.

The attacker model was made with the efficient assistance and collaboration of the aircraft manufacturer which had models that needed to be adjusted to take into account the differences between a frontal collision and a landing crash. The important aircraft characteristics, such as the various masses of their distribution, the mechanical behaviour of the different parts of the aircraft and their connections, as well as specific engine behaviour were taken into account.

The study conducted by IRSN provides information on the ultimate containment capacities, regarding both assembly stability and perforation possibilities, and material needs due to the collapse of the whole facility.

IRSN

Promoting international relations



Construction of the new "dry" storage facility of irradiated fuels on the Chernobyl site.

The purpose of the partnership between different countries is to pool resources, enrich knowledge and share competencies. It supports synergies between research and expertise.

In the areas of safety, radiation protection or security, the international openness of IRSN has grown over time. This activity is organised along three lines: deepening scientific and technical knowledge, participating in the creation of guides, recommendations or standards and supporting the reinforcement of nuclear radiation protection, safety and security abroad.

29

IRSN projects with safety or radiation protection organisations in 29 countries.

Argentina	Japan
Belgium	Morocco
Brazil	Portugal
Bulgaria	Republic of Belarus
Canada	Russia
China	Slovak Republic
Croatia	Slovenia
Cuba	South Korea
Czech Republic	Spain
Egypt	Sweden
Finland	Switzerland
Germany	Ukraine
Hungary	United Kingdom
India	United States
Italy	

> An internationally-oriented Institute

Deepening scientific and technical knowledge

By increasing knowledge, completing available tools, in particular computer codes and improving methods, international co-operation developed by IRSN in the areas of research and expertise contributes to better assess risk and improve control. Discussions and work are conducted within the framework of bilateral or multi-lateral co-operation agreements or programmes launched by international bodies and these lead to conclusions which may be subject to international consensus.

Active participation in international programmes

For the Framework Programme (FP6) of the European Atomic Energy Community (EURATOM) for research and training activities, 2002 was a transition year with the continuation of FP5 and the launch of FP6.

For the 5th PCRD, IRSN contributed significantly in 2002 to almost twenty projects: in the area of severe accidents, achievement of COLOSS (European project dedicated to the study of the core damage during a severe accident) and ENTHALPY (European base of the corium thermodynamic data); continuation of BIODOS, related to the radiation protection of workers and the public (dosimetric models), ICHEM (study of iodine behaviour in a reactor containment), BORIS (study of the migration of radioelements in the soil).

With the FP6, the European Commission suggested a completely different approach whereby the European research space structure implies that organisations join forces in networks of excellence, with long-term common means and strategies, or implement wide integrated projects. IRSN has become strongly involved in this approach: the implementation of the SARNET network of excellence on the core meltdown accidents in a pressurized water reactor (PWR) is the first example of this sort.

Lastly, within the framework of the EURADOS (European Radiation Dosimetry Group) work, co-financed by the European Commission, an intercomparison exercise regarding radiation dosimetry in the environment was conducted in 2002. During the year, IRSN was presided the EURADOS association, which brings together over 30 European organisations around two main objectives: to make progress in ionising radiation dosimetry and to promote the development of methods in this area.

Among major international programmes, IRSN continued in 2002 the Phébus programme in which 35 organisations participated and the Cabri-Water loop programme, a wide international co-operation scheme supported by the OECD. It took part in the launch of the MCCI programme (study of the molten core flow out of the vessel and interactions with containment concrete) bringing together 13 OECD countries.

Development of bilateral collaboration

2002 was the year for the renewal of the general agreement between IRSN and the JNC (Japan Nuclear Cycle Institute) and negotiations for the renewal of the general agreement with the JAERI (Japan Atomic Energy Research Institute). The latter will deal in particular with the release of fission products during a severe accident and the criticality risks in fuel cycle installations.

Furthermore, co-operation with Russian research institutes, IBRAE (Nuclear Safety Institute of the Russian Academy of Sciences) and Kurchatov, continued in 2002 around computer codes concerning severe accidents, and the negotiation to reach an agreement with the Belgian 'Association Vinçotte Nuclear' (AVN) was initiated.

Lastly, negotiations were conducted with the Bulgarian, Slovenian and Romanian organisations for their participation in the Phébus FP programme.

In the radiation protection area, a co-operation agreement was signed in December 2002 between IRSN and the Cuban CPHR (Centro de protección e higiene de las radiaciones). Initial co-operation issues concern the impact of the Chernobyl accident on health, the assessment of the impact of radioactivity on the environment, the treatment of people accidentally overexposed and the measurement of low-level radioactivity.

2002 was also a year for the reinforcement of collaboration between IRSN and Russia (Institute for Bio-physics, Moscow, and Medical Radiological Centre, Obninsk). A new wave of co-operation was launched in 2002 with the IBRAE Institute in the radio-ecology area (CITRAME project).

Taking part in the development of guides, recommendations or standards of nuclear radiation protection, safety and security

This activity is based on IRSN expertise and aims at developing documents intended, for the most part, to guide nuclear actors in their practices.

In this area, IRSN participates in the work of consultative groups, committees and working groups from the IAEA, AEN, UNSCEAR, ICRP and the European Commission...

Promoting the reinforcement of radiation protection, safety and security abroad

The safety of nuclear facilities in some foreign countries is a major issue of IRSN international co-operation regarding expertise. The purpose is to promote, through concrete collaboration, to the reinforcement of the competencies in the concerned countries.

Within this framework, Eastern European countries are the subject of several collaborative projects and most of these are conducted in close co-operation with the German GRS. They particularly result in the carrying out of assessments, the implementation or development of regulatory systems, initiation to the use of computer codes and their transfer. In particular, IRSN participated in the launch of the international review project of the safety report of the unit 1 of the Russian power plant in Kursk in 2002. It took part in the implementation of the projects related to the definitive shutdown of the Chernobyl nuclear plant, reactors 1 and 2 of Kozloduy (Bulgaria) and the Ignalina (Lithuania) reactor 1, the reduction of the risks that the current sarcophagi may have induced, as well as the overall improvements to the Ukrainian nuclear power plants, to the Metzamor Armenian plant and to the Ignalina reactor 2.

In Ukraine, a bilateral agreement signed with the Ukrainian technical safety organisation (State Scientific and Technical Centre) resulted in 2002 in the launch of common work on waste management, training and safety studies. The purpose is to compare the practices and regulations in France and the Ukraine.

Among the events in 2002, the launch in June, during the G8 summit in Kananaskis (Canada), of the "G8 international partnership of the non-proliferation of weapons of mass destruction and related materials" led public authorities to request IRSN to work on the areas of securing of nuclear materials and radioactive sources in the Russian Federation.

In Georgia, following the accident which occurred in December 2001 in Lia, where 3 inhabitants were severely exposed to radioactive sources, IRSN performed complementary expertise

on one of the patients in 2002: dosimetric reproduction and mapping of the dose received at the level of the skin area to be transplanted. This expertise was carried out to support the medical management of the victim treated in the Army Hospital of Percy (Haut-de-Seine).

It should be noted that currently relations between IRSN and its partners (safety and radiation protection technical organisations, research organisations, etc.) in Eastern Europe are developed towards more regular co-operation. IRSN promotes those changes as well as the exchange of competencies with these countries. Thus, the Institute supported the creation, in September 2002, of the CENS (Centre for Expertise in Nuclear Safety). This network, bringing together the safety organisations from Central and Eastern Europe, aims at reinforcing expertise capacities in these territories.

Beyond Europe, the reinforcement of the co-operation with China gave rise in 2002 to the adjustment of Chinese needs in the SESAME crisis management system for the French-designed Daya Bay and Ling Ao plants, as well as to many exchanges in the areas of the protection and fire fighting, the safety of experimental reactors, etc.

With India, the co-operation agreement between IRSN and the BARC (Bhabha Atomic Research Centre) was extended to cover radiation protection. Moreover, exchange concerned the application of accident computer codes for safety studies related to Indian power reactors.



Indian Delegation at IRSN.

> Close co-operation between France and Germany

Co-operation between IRSN and the GRS (Gesellschaft für Anlagen und Reaktorsicherheit) began in 1989 with the signature of a first partnership agreement, reinforced in 1998 with the creation of a board of directors bringing together the executives of both institutes. The numerous joint actions, conducted for over 10 years, have contributed to define the basis for a European approach to nuclear safety issues.

The main actions conducted in 2002

– The implementation of the FGI (French-German initiative for Chernobyl), programme intended to gather, in the form of databases, the technical information available on the consequences of the Chernobyl accident, in the Ukraine, Belarus and Russia, focusing on three issues: sarcophagi safety, transpor of radioelements in the environment and public health. These databases will be made available to public authorities, scientists and public.

In 2002, the sarcophagi safety database assessment was prepared for its integration into the international database financed by the EBRD (SIP project) within the framework of the construction of the new sarcophagi. Concurrently, the radioecology programme was completed when the radioecological data was integrated in the REDAC (Radioecological Database after Chernobyl) common database. Furthermore, the "health" aspect of the project is proceeding, with the monitoring of long-term effects of the accident on the population. Lastly, the development of an Internet site displaying the general results obtained in the three areas is in progress;

– Co-operation for improving the safety of the Eastern European nuclear plants carried out through Riskaudit, an IRSN/GRS subsidiary, and in collaboration with the other European safety technical organisations, within the framework of the PHARE and TACIS European programmes and the EBRD projects;

- Continuation of the common development of the ASTEC computer code modelling core meltdown accidents;
- Continuation of the co-operation concerning the expertise of the EPR PWR project;
- Development of the EUROSAFE project, intended to promote the future creation of a European expertise pool for nuclear safety: in 2002, the fourth EUROSAFE forum, an annual scientific and technical international event, gathered just under 500 participants in Berlin (Germany). 50 scientific and technical presentations were presented during this exhibition. The *Eurosafe Tribune*, a magazine distributed to all forum guests was launched in 2002.

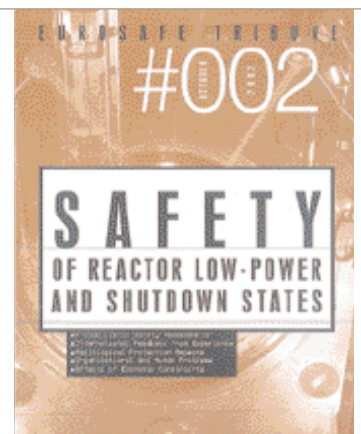
Lastly, an Internet site in French, German and English (www.eurosafe-forum.org) has been set up to inform participants on the reflections and work conducted by safety and radiation protection organisations. The implementation of the EUROSAFE approach is conducted by a programme committee comprising 6 European safety and radiation protection organisations: AVN (Belgium), CSN (Spain), GRS (Germany), HSE (United Kingdom), IRSN (France), SKI (Sweden). In 2002, the EUROSAFE approach was financially supported by the European Commission. This resulted in reinforcing its European dimension.

Concurrently, the year 2002 saw the reinforcement of AVN/GRS/IRSN co-operation. A first tripartite meeting held in December in Brussels (Belgium) to reinforce co-operation within the organisation, safety assessment methods and safety re-examination. It focused primarily on the assessment of organisations, the quality of the expertise according to the new AFNOR standard and safety re-examination.



The EUROSAFE forum organised in 2002 in Berlin brought together over 500 participants.

The EUROSAFE Tribune magazine was launched in 2001 by IRSN and the GRS, its German partner.



IRSN

Supporting information and training

Communication and information are part of the Institute's missions. To carry out these missions, a communication department was created in 2002. Its purpose is to position the Institute as an expertise and research organisation in the area of prevention and management of nuclear and radiological risks.

> Communication based on transparency and education

Information mission

The Institute supports information on the risk and prevention of nuclear and radiological risks. It therefore supports the development of a culture regarding risk in France. IRSN takes part in societal debates dealing with these issues, while listening to and taking into account public expectations regarding information.

Actions in 2002 targeting specific segments of public opinion

"Keeping a close watch on nuclear energy" targeting the general public.

For over 15 years, the travelling exhibition "Keeping a close watch on nuclear energy" has been presented to the general public and more particularly to schools. The purpose is to inform people on the risks related to nuclear power and on the measures taken to control these. It is organised by IRSN and DGSNR, in collaboration with local authorities. In 2002, it was presented in Blois, Bordeaux and Dijon and attracted over 10,000 visitors. Furthermore, the collection of IRSN booklets was extended in 2002 with a publication on radioactive waste.

Towards elected officials

With the organisation in January 2002 of a third day of information on the risks related to radon, IRSN and the

Ministry of Health extended their information actions to local representatives.

The participation in the « *Salon des maires de France* » exhibition was also the opportunity to heighten awareness of those risks among France's 36,000 mayors, in particular by distributing a letter-statement entitled "*Le radon en question*".

Annual meetings with health, environment and safety professionals. The presence in professional forums such as Medec (March 2002) and Pollutec (November 2002) are opportunities for the Institute to discuss with professionals and inform them. In the same way, the EUROSAFE forum, the European forum for safety professionals, is an exemplary partnership between IRSN and GRS. Its implementation is conducted by a programme committee comprising 6 European safety and radiation protection organisations. It is intended to promote European convergence in terms of safety practices.

For the scientific community, several scientific media were developed in 2002:

- The first scientific and technical report of IRSN, with 3,500 copies distributed in France and abroad;



IRSN exhibition at the "Salon des Maires" forum.

- The Internet site dedicated to the scientific publications of the Institute;
- A new document in the scientific collection: « Collective dose – Indications and Contraindications ».

The relations with the media are intended to provide information, either related to current events or to substantive issues. In 2002, in addition to support for the programmes and actions of the Institute, this activity focused on the creation of IRSN, Chernobyl 16 years after.

Internally, supporting the creation of IRSN

In 2002, the internal communication launched a reflection process on the values of the new Institute within working groups, with the intention being to achieve a shared vision of IRSN values. A survey was conducted on personnel expectations, based on a representative sample of the people in the Institute.

INTERNET: REAL-TIME INFORMATION

The IRSN Internet site (www.irsn.org) was set up at the beginning of 2002. At first, it was designed as an institutional site introducing the new Institute, and it has gradually integrated the contents of the IPSN and OPRI sites, enriched with new pages and a more user-friendly new home page .

A new site dedicated to IRSN research and scientific publications was launched in 2002. It gathers the references for articles, conferences and theses, published by the Institute over the last 3 years, as well as current or future theses, and information on the research teams and subjects being treated.

In 2002, the IRSN site recorded 165,700 visits by 44,500 different visitors, including almost 9,000 for the scientific site alone.

> Training

Taking part in the teaching and training effort through research is essential to confirm IRSN's mission in the area of knowledge development. This is also an opportunity to develop openness, both to scientific circles and universities. Over time, this should be an efficient means to attract young researchers and postdoctoral students to the Institute, thus generating recruitment opportunities.

Supporting teaching

As regards teaching, in addition to specific contributions by Institute agents, IRSN actively participates in training in schools of engineering and universities:

- Génie atomique (INSTN, Saclay, Essonne).
- DESS de radioprotection (Joseph-Fourier University, Grenoble, Isère).
- Nuclear power option at the Ecole nationale supérieure d'ingénieurs (ENSI) in Bourges (Cher).
- Nuclear and technologies in association option with the École des mines de Nantes (Loire-Atlantique).
- DESS Sciences des aérosols, génie de l'aérocontamination (University of Paris-XII, Val-de-Marne).

In some cases, partnership agreements have been signed, providing research programmes and reception of trainees. In 2002, agreements were signed with the Joseph-Fourier University, the ENSI of Bourges (Cher), the University of Caen (Basse-Normandie), the University of Paris-XII (Val-de-Marne) and the University of La Rochelle (Charente-Maritime).

Participating in training through research

Every year, the Institute receives doctoral and post-doctoral students in its laboratories. In 2002, autonomous management of theses and post-doctoral students was instituted, following the creation of IRSN. The theses and post-doctoral training applications are subjected to a procedure to assess subjects, conducted by two experts external to the Institute. This procedure is used to check the relevancy of the subjects, while promoting discussions between Institute researchers and external experts, teachers and university professors.

In 2002, 11 theses were defended and 22 theses were started (including 64% co-financed by companies, local authorities or research bursaries). On December 31st, 2002 13 post-doctoral trainings were in progress, including several training programmes involving foreign students (North America, South America, Asia, Eastern Europe, North Africa).

One of the objectives of training through research is to facilitate the transition from the academic world to the workplace, by enhancing the concordance between theses and professional ambitions. Over the last three years, 56% of PhD graduates and 80% of post-doctoral students went on to sign "open ended" contract. In 2002, a branch of the Bernard Grégory association was created within the Institute, supporting researchers' transition from academia to the workplace, in particular by introducing them to industry.

Similarly, the organisation of the "Formation par la recherche" days brings together almost 200 people and provides post-doctoral students with the opportunity to present the state of progression of their work in organised conferences.

On the IRSN scientific Internet site launched in 2002, the thesis section is among the most consulted areas. The use of the Internet to present completed theses, those in progress and proposals of subjects is highly appreciated among applicants.

Proceeding with quality objectives

The Institute's partners count on IRSN as an organisation recognized in the area of the nuclear and radioactivity-related risk assessment, and expect him to prove that its technical and organisational capacities enable it to ensure the quality of its activities.

In keeping with this expectation, the SEQUOIA project was launched in 2000, as a transversal and ambitious project for which the first significant stage is the certification of expertise activities scheduled for 2004.

Similarly, the Institute is constantly updating its accreditations for test and calibration activities. This guarantees the impartiality and efficiency of its methods and techniques.

SEQUOIA, a federative project

The purpose of the project is to achieve better control of all IRSN activities and their interaction: realisation of "products" (expertise, research, studies, etc.), management and support (purchasing, sales, human resources management, documentation, etc.).

After a diagnostic phase which confirmed the opportunity and the need for a project of this sort, the following phase defined the specifications of the future Quality management system, its scope, identification of the main processes, quality organisation and the method to be

used to upgrade the quality system. In this phase, the actions have been conducted to cover all technical activities of IPSN and OPRI, launched with the creation of IRSN.

The upgrading itself began in 2002. Based on a participative approach, it calls upon thematic groups, each dedicated to the study of a process and including professionals involved in each process. The co-ordination of this project and the thematic groups are supported by an outside service supplier contributing acquired experience on projects of this sort.

In 2002, work mainly focused on the areas of management, support and expertise. For management, the emphasis was on the general quality of the organisation of the Institute, monitoring of the quality system and improvement and the control of quality system documents.

For support, skills development, recruitment, purchases, sales, European research contracts and documentation (including thesis publications) were studied. Documents were produced to cover these subjects. Some have already been applied; others are in process of implementation or validation.

The communication and training actions essential for the success of the Institute's approach were listed and organised in a support plan to enable personnel to better understand the project.

ACCREDITATIONS (ISO 17025 STANDARD)	
Laboratory of studies and research in external dosimetry (Cadarache, Bouches-du-Rhône).	Calibration of instruments used in neutron dosimetry.
Laboratory of studies and research in external dosimetry (Fontenay-aux-Roses, Hauts-de-Seine).	Calibration of instruments used in photon dosimetry.
Measurement laboratory for environmental radioactivity (Orsay, Essonne).	Analysis of radionuclides present in all sample types of the environment.
Physics and Metrology Laboratory for aerosols and containment (Saclay, Essonne).	Physical tests of equipment measuring air contamination by radioactive gas.
Study laboratory for contamination, purification and ventilation transfers (Saclay).	Physical tests of ventilated equipment of personnel protection against radioactive contamination.
Environment and Response Control Department (Le Vésinet, Yvelines).	Analysis of radionuclides present in all sample types of the environment.

A policy in favour of accreditation

In 2002, IRSN defined a clear policy in favour of accreditation of its test and calibration activities, particularly when:

- Results need to comply with regulatory or contractual requirements;
- Results constitute an undeniable reference;
- Results are used to conduct expertise activities.

Accreditation projects have then been initiated in the areas related to radon, radium measurement in water and biological dosimetry.

Certification in IRSN

Within the framework of the SEQUOIA project, the purpose of IRSN is to obtain certification for all of its activities. Certification and certification renewal approaches were conducted by units intervening in specific areas or to meet originators' requirements.

This is the case for the CTHIR (Technical Centre for the Approval of Radiological Protection Instrumentation) which obtained certification in 2002 and for the OAR (Radiation protection assistance office) which initiated the actions necessary for renewing certification obtained in 1999.

A new accreditation baseline in 2002

In 2002, laboratories were affected by the baseline change, produced after the publication of the new ISO 17025 standards. Compliance to this new baseline implied significant changes, both at the organisational and technical levels. This objective was met by all units which obtained renewal of their accreditation. Today, 6 units have accreditation from the COFRAC (see box).



CERTIFICATION (2000 VERSION OF ISO 9001 STANDARD)

Technical Centre for the Approval of Radiological Protection Instrumentation (Saclay).

Assessment of the radiation protection instrumentation for nuclear and medical industries and industries using ionising radiation.

Radiation protection assistance office (Fontenay-aux-Roses).

- Acceptance and control of high efficiency filters and iodine traps of nuclear facilities.
- Acceptance of absorbing samples of the purification systems for radioactive gaseous effluents.
- Measurement of radon in the environment and buildings.



Gamma spectrometry laboratory (left) and benzene synthesis laboratory (right): two accredited IRSN activities.



Human resources and labour relations: supporting the implementation and the development of IRSN

Since its creation in February 2002, IRSN has exercised its responsibilities as an employer, previously assumed by the CEA and by OPRI. This structured 2002 activities around three issues:

- The administrative acts necessary for the exercise of the employer responsibility and employees' personal management;
- Representative personnel authorities;
- Management procedures and tools.

Within this context, it is essential to create an attractive environment so that employees who participate in the development of the new Institute find convincing reasons to pursue their career, including those employees made available to IRSN by the CEA and employees who benefit from the status of established civil servants.

At the time of the creation of the IRSN, over half of the employees contributing to IRSN activities were employed by the CEA (800 persons) and 200 were employed by the former OPRI or were civil servants. According to the provisions of the decree dated February 22nd, 2002, CEA employees made available to IRSN have a three-year period from the date of implementation of the decree during which they may express their desire to pursue their career in the CEA or choose IRSN status.

Integration of OPRI personnel

Among the actions directly related to the creation of IRSN, the integration of OPRI personnel required a programme of explanation through information meetings and personal interviews. The purpose was to propose to OPRI agents, a public administrative establishment, contracts under private-sector law corresponding to the status of the new Institute. On December 31st, 2002, out of 197 OPRI employees, 165 had chosen an IRSN contract.

Representative authorities to ensure the labour relations dialogue and negotiate a company-wide agreement

A company-wide agreement is negotiated, according to the provisions of the decree of February 22nd, 2002, on

the basis of the provisions of the CEA labour convention, appropriate to the environment, size and activities of the Institute.

This project mobilises, both General Management, which considers it as a central aspect of the human resources management of the company, and Human Resources Management, which provides its experience and logistical support to the numerous meetings held on this issue. This work was particularly useful to propose and negotiate developments in the structure and general economic conditions for wage increases and advancement time-tables of non-management employees.

The end of the year was dedicated to the preparation of the election of personnel representatives for the various legal and conventional authorities which will be directly concerned by the quality of the dialogue and discussions between employees and management.

To offer career opportunities to employees beyond IRSN activities, conditions of mobility between the CEA and IRSN were discussed and resulted in a draft convention between both organisations, transmitted to the concerned ministries and to the Ministry of Budget, as provided for in the decree of February 22nd, 2002. The convention is intended to encourage exchanges of skills to mutually enrich the organisations and offer career opportunities for employees from both bodies. The same type of agreement will be developed with other organisations specialising in areas related to IRSN activities. On December 31st, 2002, 43 IRSN employees were made available to other organisations, including the DGSNR.

Development and control of management procedures and tools

In terms of compensation policies, the payroll package adopted by the Institute was structured to take into account the diversity of personnel statuses and it has been operational since the end of February 2002.

Over 17 different status categories are managed by the department responsible for this activity.

This structure and its management have been and remain a demanding activity with significant dedicated resources. In Human Resources management, all employees and





Every year, IRSN receives doctoral and post-doctoral students. Almost 50% of post-doctoral graduates were hired by IRSN lasting recent years.



managers are constantly dedicated to meeting the justified expectations of every employee to receive wage slips within deadline.

The IT system was also improved so that fees for missions carried out are paid as soon as possible and in compliance with the current regulatory provisions.

Permanence and quality of personnel administration activities and the exercise of employer's responsibilities

In addition to the projects linked to the implementation of the new Institute, Human Resources management carried out its basic missions so that laboratories and support units continue to have the means required to achieve their operational objectives. It therefore contributed by recruiting 150 people, by establishing and managing 266 files of temporary employees hired to support the various teams, by conducting induction operations such as the reception and training of new recruits. Management of professional travel was ensured for France and abroad (more than 8,700 missions treated and finalised in 2002).

In the training area, the activity represented a budget of €1.4 million in 2002, i.e. 6,000 training hours in three areas: scientific and technical topics (70%), languages and office process modernisation.

In 2002, IRSN received 120 trainees, including 70% in their fifth year of university studies or completing an engineering school. Besides, about twenty foreign contributors were received for a stay of six months on average. These trainees come mainly from the Institute's partner organisations and follow training within the framework of IRSN international agreements.

Among the employer's duties, the relations with all labour organisations and administrations intervening in the regulation and control of EPICs (Public establishments of an industrial and commercial nature) have been defined. The production of legal and regulatory information has been implemented and is now subject to presentations on a regular basis.

KEY FIGURES AND DATES (ON DECEMBER 31st, 2002)

- 1,437 workstations.
- 66% of employees with management status: engineers and management personnel.
- 34% of employees have non-management status: technicians, administrative and logistics support personnel.
- 42% of employees work directly for IRSN (602 persons).
- 58% of professionals are made available to IRSN by the CEA (835 persons).
- 700 IRSN pay slips are produced every month.
- 6,000 training hours were dispensed in 2002.
- 8,700 missions were completed.
- 120 trainee files were processed.
- Personnel representatives and trade union representatives in the Works Committee were elected on January 23rd, 2003 (first round) and on February 6th, 2003 (runoff).



Meetings related to IRSN organisation held throughout the year 2002.

IRSN 2002 budget

IRSN was created in 2002 as an EPIC (*Établissement Public à Caractère Industriel et Commercial*), a specific French status for public institutions with industrial and commercial activities, supervised by a designated accountant. This resulted in changes in the Institute's tax obligations and necessitated the implementation of new organizational, management and accounting tools to comply with this new status.

This change in status immediately impacted two areas of the financial reporting system:

- Forecasting was established on the basis of a 12-month period, but operations were carried out over a 10-month period;
- Documents were presented in the M9-5 standard accounting format.

The Institute's total revenues totalled €214.5 million, with 83% being provided by the French Ministry for the Environment and Sustainable Development. The remainder, i.e. 17%, was generated by services provided to third parties or through mutually-financed programmes, in particular with EDF and COGEMA.

Expenses for operating costs amounted to €200.4 million, with only €25,120,486.08 in personnel costs. This low level is due to the fact that the majority of employees formerly with the IPSN are still employed by the CEA, which invoices their cost to the Institute.

The transfer of OPRI and IPSN assets has not yet been fully completed and therefore these accounting entries are not included in the IRSN balance sheet. Similarly, no depreciation write-offs have been entered into the 2002 annual accounts.

The balance between revenues and expenses amounts to €14.1 million in underlying earnings, providing nearly complete organic coverage of investments, which stand at €14.7 million for the fiscal year.

In operational terms, the overall balance in working capital was reduced by €0.7 million.



1 – RECONCILIATION SUMMARY OF ESTIMATES AND REALISATION

A – Profit & Loss account (in millions of euros)

	Costs		Revenues		
	E	R	E	R	
Profit & Loss account					
Personnel costs	106.0	25.1	38.5	34.6	Sales: Provision of services
			241.8	178.5	Public subsidies
Other operating costs	154.7	175.3	0.1	1.4	Other operating revenues
Total costs	260.7	200.4	280.4	214.5	Total revenues
Earnings (Profit)	19.8	14.1	–	–	Negative earnings (Loss)
Total balance on Profit & Loss account	280.4	214.5	280.4	214.5	Total balance on Profit & Loss account

E = Estimates 12 months – R = Realisation 10 months.

B – Cash flow (in millions of euros)

	Capacity		Deficit		
	E	R	E	R	
Earnings (Profit)	19.8	14.0			Negative earnings (Loss)
+ Book value of assets sold					– Revenues from assets sold
+ Appropriations to amortisation and provisions	0.0	0.0			– Revenues from amortization compensation
					– Share of subsidies transferred to earnings
					– Adjustments to amortisation and provisions
Subtotal	19.8	14.0			Subtotal
Cash Inflow	19.8	14.0			Cash Outflow

E = Estimates 12 months – R = Realisation 10 months.

C – Reconciliation of cash flow to movement in net funds (in millions of euros)

	Costs		Revenues		
	E	R	E	R	
Cash Inflow			19.8	14	Cash Outflow
Acquisitions of tangible and intangible assets	19.8	14.7			Public investment subsidies
Long-term investments					Other resources (excluding internal transactions)
Total employees	19.8	14.7	19.8	14	Total resources
Contribution of working capital				0.7	Deduction from working capital
Total balance of table	19.8	14.7	19.8	14.8	Total balance of table

E = Estimates 12 months – R = Realisation 10 months.

2 – PROFIT & LOSS ACCOUNT

A – Income (in millions of euros)

Earnings (before taxes)	Financial Year 2002 (10 months)
Operating earnings	213.5
Sales of merchandise	
Production sales	
• Work	
• Provision of services, studies & activities	34.7
Net turnover	34.7
Closing stock	
• Production in progress	
• Services in progress	
• Revenues	
Capitalized production	
Operating subsidies	178.6
Adjustments to amortisation and provisions	
Transfers of liabilities	0.1
Other revenues	0.1
Investment earnings	1
From holdings	
Other securities of fixed asset receivables	
Other interest and similar earnings	
Adjustments to provisions and transfers of financial liabilities	
Positive exchange rate differences	
Net income on transfers of investment securities	1
Exceptional earnings	0
On management transactions	
On capital transactions	
• Earnings from asset transfers	
• Investment subsidies transferred to the year's Profit & Loss Account	
• Others	
Amortisation compensation	
Adjustments to provisions and transfers of non-recurrent liabilities	
Total earnings	214.7
Debit balance = Loss	
OVERALL TOTAL	214.5

B – Liabilities (in millions of euros)

Liabilities (excluding taxes)	Financial year 2002 (10 months)
Operating liabilities	200.5
Purchase costs of merchandise sold during the year	
• Merchandise purchases	
• Fluctuation in merchandise stocks	
Costs related to third parties	
• Purchases of supplies in hand	
– Raw materials	
– Work	
– Others (studies, services)	
• Fluctuation in stock of supplies	
• Subcontracting costs	29.1
• Purchases of equipment & supplies not in stock	19
• External services	123.8
Taxes and similar payments	
– Remuneration costs	0.6
– Others	2.9
Personnel costs	
– Wages & salaries	17.7
– Social security charges	7.4
Appropriations to amortisation and provisions	
– On fixed capital: appropriations to amortisation	
– On fixed capital: appropriations to provisions	
– On current assets: appropriations to provisions	
– For contingent liabilities: appropriations to provisions	
Other liabilities	
Investment liabilities	0
Appropriations to amortisation and provisions	
Interest and similar liabilities	
Negative exchange rate differences	
Net liabilities on transfers of investment securities	
Non-recurrent liabilities	0
On management transactions	
On capital transactions	
• Accounting value of transferred fixed and funded items	
• Other	
Appropriations to amortisation and provisions	
• Appropriations to regulated provisions	
• Appropriations to amortisation and other provisions	
Total liabilities	200.5
Credit balance = Profit	14
OVERALL TOTAL	214.5

3 – BALANCE SHEET

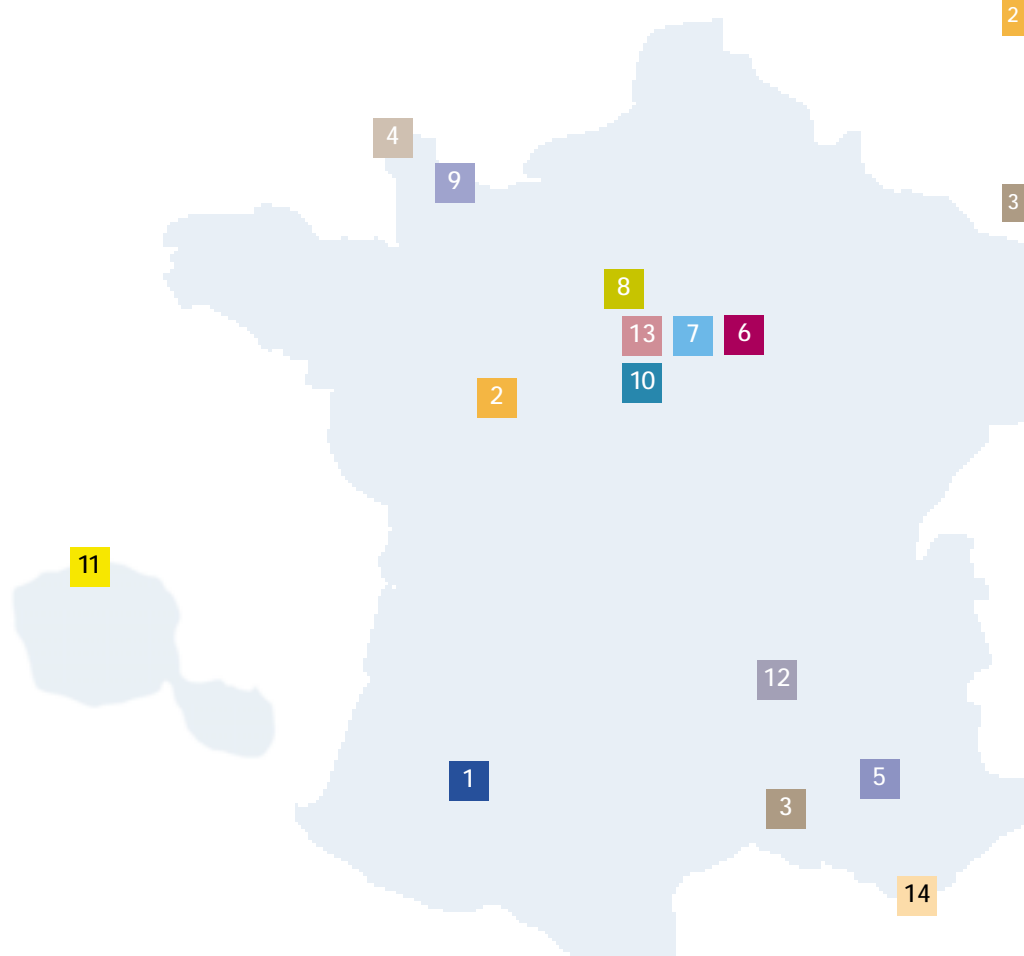
A – Assets (in millions of euros)

ASSETS	Financial Year 2002 (10 months)		
	Gross	Amortisation and provisions (to deduct)	Net
Fixed assets			
Intangible assets			
Initial costs			
R&D costs			
Concessions, patents, licences, brands, processes, software and similar duties and costs	1.3		1.3
Goodwill			
Others			
Intangible assets in progress	0.1		0.1
Advances and deposits			
Tangible assets			
Land			
Buildings & structures	0.8		0.8
Technical installations, equipment and plant	4.8		4.8
Others	3.1		3.1
Tangible assets in progress	4.6		4.6
Advances and deposits			
Investment assets			
Holdings			
Receivables related to holdings			
Other fixed securities			
Loans			
Others			
Total (I)	14.7	0	14.7
Current assets			
Stock and work-in-progress			
Raw materials and other supplies			
Production in progress (goods & services)			
Work in progress			
Semi-finished & finished products			
Merchandise			
Advances & deposits on orders	27.6		27.6
Operating receivables			
Client receivables & connected accounts	35.7	0.1	35.6
Others	54.9		54.9
Miscellaneous receivables			
Investment securities	47.1		47.1
Shares			
Other securities			
Liquid assets	0.3		0.3
Deferred charges			
Prepayments			
Total (II)	165.6	0.1	165.5
Charges to be allocated over several financial years (III)			
Loan redemption premiums (IV)			
Assets translation variance (V)			
OVERALL TOTAL	180.3	0.1	180.2

B – Liabilities (in millions of euros)

LIABILITIES	Financial Year 2002 (10 months)
Shareholder Equity Funds	
Allowances	
Addition to allowances. State	
Addition to allowances (bodies other than the State)	
Equity	
Other additions to allowances. State	
Other additions to allowances. Other bodies	
Capital donations	
Variance in revaluation	
Reserves	
Regulated reserves	
Others	
Carried forward	
Financial year earnings (Profit or loss)	14.1
Subtotal: Net equity	14.1
Investment subsidies	
Regulated provisions	
Total I	14.1
Contingent liability provisions	
Provision for risks	
Provision for liabilities	
Total II	0
Debts	
Financial debts	
Debtenture loans	
Loans & debts from credit institutions	
Miscellaneous financial loans & debts	-0.2
Advances and deposits received on current orders	2.4
Operating debts	
Supplier debts and connected accounts	84.3
Fiscal & social security debts	54.8
Other	
Miscellaneous debts	
Debts on fixed capital and connected accounts	6.8
Other debts	17.9
Miscellaneous accruals	
Deferred earnings	0.1
Total III	166.1
Liabilities translation variance (IV)	
OVERALL TOTAL (I+II+III+IV)	180.2

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Glossary

A

ADEME: Agency for the Environment and Energy Control (France).

Aerosol: Dispersion, in very fine particles (about one micron), of a liquid or solid in a gas (air or oxygen).

AFNOR: French standardisation institute.

AFSSE: French Agency for Environmental Safety.

Alpha (α symbol): Radiation composed of helium 4 nuclei, highly ionising but not very penetrating. A sheet of paper is sufficient to stop alpha radiation.

AMANDE: Accelerator for metrology and neutron applications for external dosimetry.

ANDRA: National Agency for Radioactive Waste Management (France).

ASTEC: Accident Source Term Evaluation Code, systems of software developed in collaboration by IRSN and the GRS to assess the physical phenomena intervening during an accident of core meltdown of a pressurized water reactor.

AVN: Association Vinçotte Nucléaire (Belgium).

B

BARC: Bhabha Atomic Research Centre (India).

Becquerel (Bq): Official international unit for radioactivity measurement. The Becquerel (Bq) is equal to one disintegration per second.

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.

BIPM: International bureau of weights and measures.

BLEVE: Boiling Liquid Expanding Vapour Explosion.

BNEN: Standardization bureau for nuclear equipment.

BNI: Basic Nuclear Installation.

BNM: National metrology bureau (France).

BORIS: Bioavailability of Radionuclides in Soils.

Burn up fraction: Thermal energy produced by the nuclear fissions in a fuel mass unit. It is measured in megawatt days per ton (MWj/t).

C

CABRI: Test reactor for fuel safety used by the IRSN.

CARMELA: IRSN research programme on fires in nuclear facilities aimed at gaining further insight into electrical cabinet fires.

CAROL: CAmargue-Rhône-Languedoc, project for studying the distribution of artificial radionuclides in the Lower-Rhône region.

CATHARE: Advanced thermal-hydraulic code applied to pressurized water reactors.

CEA: Atomic Energy Commission (France).

Cesium (Cs, atomic number 55): Noble, toxic metal whose characteristics are comparable to those of potassium.

CHU: French university hospital.

Primary cooling 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.

CIREA: Interministerial commission for artificial radioelements

CLI: Local information commission.

CNRS: French National Centre for Scientific Research (France).

COFRAC: French accreditation committee.

COGÉMA: Nuclear matter company (France).

COLOSS: European project devoted to the study of core degradation in the event of a severe accident.

Containment building or reactor building: Leak-tight concrete building housing the reactor pressure vessel, the primary system, the steam generators and the main auxiliaries ensuring reactor safety.

Core: Area of the nuclear reactor where nuclear reactions occur.

CRISTAL: New French criticality-safety package developed as part of a joint project between IRSN, CEA and COGEMA. It aims at assessing the criticality risk in all nuclear facilities and transport packages where fissile materials are used.

Criticality: Risk of 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.

CSN: Consejo de Seguridad Nuclear (Spain).

CTC: IRSN emergency response centre.

CThIR: Technical Centre for the Approval of Radiological Protection Instrumentation.

D

- DGA:** General delegation for armaments.
- DGAC:** General Directorate of Civil Aviation.
- DGEMP:** General directorate for energy and raw materials.
- DGS:** Directorate General for Health.
- DGSNR:** General Directorate for Nuclear Safety and Radiation Protection.
- DIAPLU:** Study project on the PLUtonium behaviour in the DIAgegenesis of marine sediments.
- DISPRO:** Study project on near-field dispersion.
- DIVA:** Devices for the study of fires, ventilation and airborne contamination.
- Dosimetry:** Detection, by assessment or measurement, of the dose of radiation absorbed by a substance or person.
- DRIRE:** Regional Agency for Industry, Research and the Environment.
- DSND:** Delegate for nuclear safety and radiation protection for activities and installations concerned by national defence provisions.
- DSV:** Department of life sciences.

E

- EBRD:** European Bank for Reconstruction and Development.
- EDF:** French national electricity utility company.
- ENTHALPY:** European corium thermodynamic database.
- ENVIRHOM:** IRSN health and environment research programme to study the effects of chronic exposure to low-dose radionuclides.
- ÉPIC:** Public establishment of an industrial and commercial nature.
- EURADOS:** EUropean RAdiation DOSimetry group.
- EURATOM:** European Atomic Energy Community.
- EURODIF:** European uranium enrichment by gaseous diffusion plant.
- EVIDOS:** Evaluation of Individual Dosimetry in Mixed Neutron-Proton Fields: research programme funded by the European Community.
- EVITA:** European Validation of the Integral Code ASTEC.

F

- FASSET:** Framework for ASSessment of Environmental impacT.
- FLAMMES:** Software describing the evolution of carbonated product fires developed by IRSN.
- FLIP:** Liquid fuel fire interacting with a wall.

Framatome: Manufacturer of nuclear steam supply systems.

Fuel assembly: Cluster of fuel rods, connected with a metallic structure, used in nuclear reactors.

G

- Gamma (γ symbol):** Highly penetrating but not very ionising electromagnetic radiation, emitted during the disintegration of radioactive elements. This type of radiation is stopped by concrete or lead screens.
- GEA:** Atomic study group.
- GRNC:** Nord-Cotentin radioecology group.
- GRS:** Gesellschaft für Anlagen und Reaktorsicherheit (Germany).
- GSNIEN:** Group of scientists for information on nuclear energy (France).

H

- HAT:** Human Alimentary Tract Model.
- HFD:** High Civil Servant for Defence.
- HSE:** Health and Safety Executive (United Kingdom).

I

- IAEA:** International Atomic Energy Agency.
- IARC:** International Agency for Research on Cancer.
- IBRAE:** Nuclear safety institute of the Russian Academy of Sciences.
- ICARE:** Interpretation of damaged cores for water-cooled reactors: software simulating the degradation of a PWR core during a severe accident.
- ICHEM:** European Iodine Chemistry Project.
- ICPE:** Listed environmental protection facility.
- ICRP:** International Commission on Radiological Protection.
- IFA:** French-German initiative for Chernobyl.
- IFREMER:** French research institute for exploitation of the sea.
- IGR:** Gustave Roussy Institute (France).
- IGS:** Institute of Geological Sciences.
- ILL:** Laue-Langevin Institute (France).
- INBS:** Secret basic nuclear installation.

INDOS: International Dosimetry.

INERIS: National institute for the industrial environment and hazards (France).

INSERM: National health and medical research institute (France).

INSTN: National institute for nuclear science and technology.

INSU: National institute for sciences of the universe.

InVs: French health watch institute.

IPSN: Institute for protection and nuclear safety (France).

IRSN: Nuclear safety and radioprotection institute (France).

ISO: International Standards Organisation.

ISO 9001: European standard for quality management systems.

Isotope: 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.

J

JAERI: Japan Atomic Energy Research Institute.

JNC: Japan Nuclear Cycle Institute.

L

LOCA: Loss Of Coolant Accident.

LTCRA: Cellular therapy and accidental radiation protection laboratory.

M

MCCI: Molten-core Concrete Interaction.

MEDEC: French trade fair for professionals in the health sector.

MINEFI: Ministry of the Economy, Finance and Industry (France).

MOX: Fuels of mixed uranium and plutonium oxides.

MWe: MegaWatt electric.

N

NEA: OECD Nuclear Energy Agency.

Nuclear fuel: Fissile material (able to undergo a fission reaction) 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 materials: Materials which can be used to manufacture an explosive nuclear device. They are defined from their fissile (for a fission device), fusible (for a thermonuclear bomb), or fertile (capacity to produce fissile or fusible materials) characteristics. French legislation retains 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, manufacturing, operation and decommissioning of nuclear facilities to prevent accident and to limit their effects.

O

OAR: Radiation protection assistance office.

OECD: Organisation for Economic Co-operation and Development.

OPCW: Organisation for the Prohibition of Chemical Weapons.

OPERA: Permanent environmental radioactivity observatory.

OPRI: Office for Protection against Ionising Radiation (France).

P

PCRD: Research and development framework programme (European Community).

PHARE: European co-operation programme with the countries of Central Europe.

Phébus: Experimental reactor.

Phébus FP: Research programme devoted to the study of fission product (FP) behaviour.

Phénix: 250 MWe fast neutron reactor.

PIC: Common interested 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.

PSA: Probabilistic Safety Analyses.

PWR: Pressurized Water Reactor.

R

Radiation protection: Set of measures intended to ensure the sanitary protection of people and workers against negative effects of ionising radiation.

Radioactivity: Property of certain chemical elements whose nuclei spontaneously disintegrate into other elements emitting ionising radiation.

Radioelement: Natural or artificial radioactive element.

Radionuclide: Radioactive isotope of an element.

RAFT: Reactivity Accident Fuel Test, IRSN research programme developed in collaboration with EDF and JNC (Japan) concerning the safety of the fast neutron reactors.

REMORA: Study project on the Radionuclide REMobilisation in the Rhône prodelta.

REMOTRANS: REMobilisation, long distance TRANSport and Bioavailability of Radionuclides in Marine sediments.

S

SARA: Automated monitoring of aerosol radioactivity.

SARNET: Severe Accident Research Network.

SCANAIR: Computer system for the analysis of IRSN injection reactivity accidents.

SEQUOIA: Progressive quality system, IRSN's goal for the future.

SÉSAME: Accident situation progression plan and assessment methods. This is a computer system developed by IRSN to assess the releases produced by a pressurized water reactor in case of accident.

SIEVERT: Information and assessment system of the exposure to cosmic radiation during flights.

SILÈNE: An IRSN experimental reactor used for criticality experiments.

SIMEVENT: Ventilation simulation software developed as part of a joint project between IRSN, SGN and COGEMA.

SIP: Shelter Implementation Plan.

SISERI: Ionising radiation exposure monitoring information system.

SKI: Statens Kärnkraftinspektion (Sweden).

SSTC: State Scientific and Technical Centre (Ukraine).

STARMANIA: Station for the study of airborne contamination transfer and mechanical strength under incident and accident conditions.

SYMBIOSE: SYstemic Approach for Modelling the Fate of Chemicals in BIOSphere and Ecosystems.

T

TACIS: Technical Assistance for Commonwealth of Independent States.

Technicatome: Engineering company specialising in safety and reliability systems in severe environments.

TRANSAT: Study project on water ATmosphere TRANSfert.

U

UIAR: Ukrainian Institute of Agricultural Radiology.

Unit: Power production unit including a boiler and a turbo-generator set. A nuclear unit is mainly defined by its type of reactor and the power of its turbo-generator.

UNSCEAR: United Nations Scientific Committee on the Effect of Atomic Radiation.

UO₂: Uranium dioxide.

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