For many years, industry and research have been using sources of ionising radiation in a wide variety of applications and locations. The issue for the radiation protection regulations currently in force is to check that, despite this great diversity, the safety of workers, the public and the environment is guaranteed. It is thus important to be able to supervise the conditions of production, possession, use and disposal of the sources. The investigations carried out by the ASN in 2004 confirmed that the means devoted to radiation protection in the industrial and research worlds vary widely. This situation led the ASN to define areas for action, in the light of these existing resources. This year, particular efforts were therefore focused on the manufacturers and suppliers of radionuclide sources, as they have considerable responsibility for the entire life of the radioactive sources, from production up to final disposal. It is therefore important for their situation with respect to radiation protection rules to be unambiguous. At the same time, the ASN continued gradually to acquire the means necessary for handling all its radiation protection supervision duties.

1 PRESENTATION OF INDUSTRIAL AND RESEARCH ACTIVITIES USING IONISING RADIATION

Industry and research employ radiation produced either by radionuclides - primarily artificial - in sealed or unsealed sources, or by electrical generators. The main applications in these sectors are presented below.

1 | 1

Sealed radioactive sources

The main uses of sealed radioactive sources include the following.

1 | 1 | 1

Industrial irradiation

This is used for sterilising medical equipment, pharmaceutical or cosmetic products and for conservation of foodstuffs. At low doses, irradiation inhibits germination (potatoes, onions, garlic, ginger), kills insects and parasites in cereals, leguminous plants, fresh and dried fruits, fish and meat, and slows down the physiological process of decomposition of fresh fruits and vegetables.

At medium doses, ionisation by irradiation prolongs the shelf-life of fresh fish and strawberries, eliminates deterioration agents and pathogenic micro-organisms in shellfish and meat (fresh or frozen), and technically improves foodstuffs, for example by increasing juice production from grapes or reducing the cooking time of dehydrated vegetables.

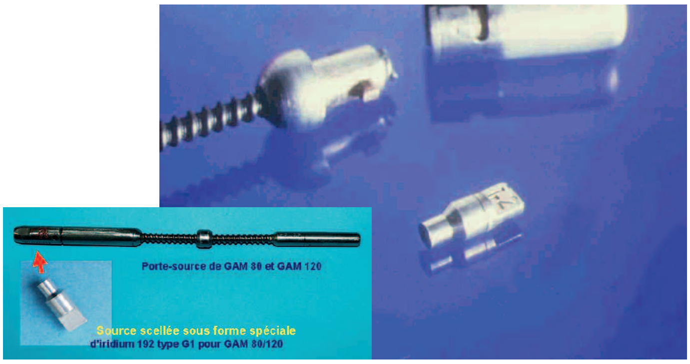
At high doses, ionisation offers industrial sterilisation of meat and seafood, of ready-to-eat foods, of hospital meals and decontamination of certain food additives and ingredients such as spices, gums, and enzyme preparations. These consumer product irradiation techniques may be authorised because once the products are treated, they show no signs of added artificial radioactivity. Industrial irradiators use cobalt 60 sources, the total activity of which can exceed 250,000 TBq. Some of these installations are classified as basic nuclear installations (BNIs).

1 | 1 | 2

Non-destructive testing

Of the non-destructive testing techniques, gamma radiography in particular uses radioactive sources. It is used to inspect homogeneity defects in metal, particularly in weld beads. It uses iridium 192 sources and cobalt 60, with activity not exceeding about twenty terabecquerels. A gamma radiography appliance mainly comprises:
- a source applicator, used as a storage container when the source is not in use and for transport;
- an ejector tube and remote control designed to move the source between the applicator and the object to be radiographed, while protecting the operator who can remain at a distance from the source;
- a radioactive source inserted into a source-holder.

The gammagraph is usually a mobile device that can be moved from one site to another.



Gammagraphy equipment and its radioactive source

1 | 1 | 3

Checking of parameters

The radionuclides most frequently employed are krypton 85, caesium 137, americium 241, cobalt 60 and prometheum 147. The source activity levels are between a few kilo becquerels and a few giga becquerels. These sources are used for the following purposes:
- atmospheric dust measurement; the air is permanently filtered through a tape running at a controlled speed, placed between source and detector. The intensity of radiation received by the detector depends on the amount of dust on the filter, which enables this amount to be determined. The most commonly used sources are carbon 14 (activity 3.5 MBq) or prometheum 147 (activity 9 MBq). These measurements are particularly used for air quality monitoring by checking the dust content of discharges from plants;
- basis weight measurement: a beta radiation beam passes through the paper and then is received by a detector. The signal attenuation on this detector allows to know the paper density and thus the basis weight. The sources used are generally krypton 85, prometheum 147 and americium 241 with activity levels lower than 3 GBq;
- liquid level measurement: a beam of gamma radiation passes through the container filled with a liquid. It is received by a detector positioned opposite. The signal attenuation on this detector provides the level of filling of the container and automatic triggering of certain operations (stop/continue filling, alarm, etc.). The radionuclides used depend on the characteristics of the container and the con-

tent. As applicable, americium 241 (activity 1.7 GBq), caesium 137 - barium 137m (activity 37 MBq) are generally used;

• density measurement and weighing: the principle is the same as for the above two measurements. The sources used are generally americium 241 (activity 2 GBq), caesium 137-barium 137m (activity 100 MBq) or cobalt 60 (30 GBq);

• soil density and humidity measurement, or gammadensimetry, in particular in agriculture and public works. These devices operate with a pair of americium-beryllium sources and a caesium 137 source;

• logging, which enables the geological properties of the sub-soil to be examined by inserting a measurement probe comprising a source of cobalt 60, caesium 137, americium-beryllium or californium 252.

1 | 1 | 4

Other common applications

Sealed sources can also be used for:

• eliminating static electricity;

• smoke detection (see box);

• calibration of measuring instruments (radiation metrology);

Smoke detection

The aim is to signal an outbreak of fire as early as possible, by detecting the smoke produced. The devices used comprise two ionisation chambers, including one reference chamber being tight to the ambient gas, while the other lets combustion gases enter. The intensity of the current passing through the reference chamber is compared with that of the current passing through the measurement chamber. When the difference in intensity is higher than a preset threshold, an alarm is triggered. The gases contained in the reference chamber are ionised by emission of radiation from a sealed source. Although several types of radioelements were used in the past (americium 241, plutonium 238, nickel 63, krypton 85), at present only americium is used, with an activity not in excess of 37 kBq.

Domestic use of smoke detectors employing radioactive sources is prohibited in France. This ban does not apply to the common areas of residential buildings. The licences are issued under a procedure tailored to the constraints arising from use of these appliances.

In recent years, progress in the design of these devices has led to a reduction in the level of activity they need to operate, with some of them using a 10 kBq source. At the same time, the ASN has started discussions with the profession, concerning the eventual withdrawal of smoke detectors containing radioactive sources. It is planned to put an end in 2007 to the sale of new devices, except to replace devices for maintenance of detection systems (maintenance means the replacement of existing devices and/or the addition of detectors to an existing line), followed in 2009 by a total interruption of the sale of new devices. From this date, only the reconditioning of old devices would be authorised for two maintenance cycles of a maximum of four years each.

Smoke detector with its radioactive source

• practical teaching work concerning radioactivity phenomena;
• electron capture detectors using sources of nickel 63 or tritium in gaseous phase chromatographs. This technique can be used to detect and dose various elements. These often portable devices are used to dose pesticides or detect explosives, drugs or toxic products;
• detection using X-ray fluorescence devices. This technique is particularly useful in detecting lead in paint (see box).

Lead detection in paint

Saturnism is a disease caused by lead poisoning. This poisoning usually results from ingestion or inhalation of dust from paint containing lead salts. This type of paint is usually encountered in older housing (until 1948), as lead is currently prohibited as an additive to paint.

A legislative framework aimed at combating social exclusion sets an obligation for action to prevent child saturnism by requiring that the concentration of lead in paint be controlled. Article 3 of the order of 12 July 1999 concerning diagnosis of the risk of intoxication from the lead contained in paint, implementing article R. 32-2 of the Public Health Code, states that “the lead will preferably be measured using a portable X-ray fluorescence device”. This non-destructive analysis method allows instantaneous detection of lead in a coating.

The material to be analysed is excited by an input of energy, to obtain a spectrum in which the presence of the line characteristic of lead can be recognised and quantified. The measurement principle is as follows: the gamma photon emitted by a radionuclide interacts photoelectrically to eject an electron from an atom of the target. De-excitation of the atom to return it to its equilibrium state, leads to emission of an X-ray photon (X-ray fluorescence), the energy of which is characteristic of the element to be analysed (lead). The X-ray photons emitted are counted by a detector and their number is proportional to the number of atoms per unit surface area of the element looked for. Measurement precision is currently 0.058 mg of lead per cm^2 of surface.

The appliances, which are portable, use sources of cadmium 109 (half-life 464 days) or cobalt 57 (half-life 270 days). The activity of these sources is about 400 MBq.

In 2004, a new type of device came onto the market, containing no radioactive source and using an electrical generator working on the same principle as the emission of X-ray fluorescence photons.

These various devices are used by a wide variety of organisations, mainly consulting firms, architects, surveyors, solicitors, real estate agents and building managers. The ASN therefore ensures that the appliances offer radiation protection guarantees appropriate to the conditions of use and sets obligations on the users for handling and storage of these appliances, in order to prevent unauthorised loans and theft.

Portable X-ray fluorescence equipment to detect lead in paint

1 | 2

Unsealed radioactive sources

The main radioelements used in unsealed sources are phosphorus 32 or 33, carbon 14, sulphur 35, chromium 51, iodine 125 and tritium.. They are used as tracers for calibration and teaching. Radioactive tracers incorporated into molecules is common practice in biological research. They are thus a powerful investigative tool in cellular and molecular biology. Unsealed sources are also used as tracers for measuring wear, searching for leaks, for friction research, for building hydrodynamic models and in hydrology. The following box describes a particular application of unsealed sources.

Uses of radioactivity in molecular biology

Molecular biology is a scientific discipline which studies the molecules carrying the hereditary message:

- deoxyribonucleic acid (DNA). DNA carries genetic information, because it has the particularity of replicating and being transmitted to the descendants. It has a data storage role;
- ribonucleic acid (RNA). RNA plays a key role in synthesising proteins. It is the messenger of the genetic data (gene transcription).

In these molecules, molecular biology analyses the structure of the genome and its alterations (mutations) as well as the mechanisms of the normal and pathological expression of the genes. The term molecular biology is sometimes used to designate gene study techniques.

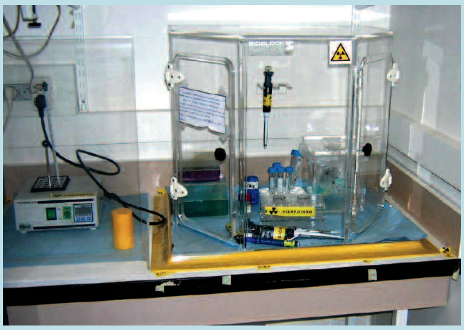
These techniques include:

- the Southern technique, developed by the British researcher E. Southern in 1975. It is used to identify and observe a DNA sequence or a gene without isolating it;
- the Northern technique, in which the process - identical to that of the Southern technique - is applied to RNA;
- the Western-Blot reaction which is used to look for antigenic (for example viral) proteins or antibodies, in particular in blood serum.

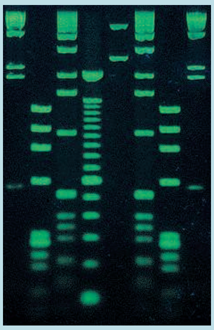
These techniques use a nucleic probe or an antibody marked with a radioactive isotope allowing identification, visualisation and quantification by autoradiography, in other words by obtaining an image produced on a photographic film (or emulsion) placed in contact with the preparation, through the radiation of the radioactive marker. For example, in the case of marking of a DNA or RNA probe, an atom of radioactive phosphorus (^{32}P or ^{33}P) or radioactive sulphur (^{35}S) is incorporated into a nucleotidic sequence. The activity levels involved are about 2 to 4 MBq;

For in vivo marking techniques, thymidine marked with tritium (^{3}H) is generally used for DNA and uridine marked with tritium for RNA. The activity levels employed are about 10 to 100 MBq.

Although radioactive marking techniques are common, in certain cases, other “cold” marking methods (in other words without radionuclides) can also be used to visualise macromolecules. These are for example fluorescent, chemical or bioluminescent markers, or detection of the {enzyme-substrate} complex using colorimetry.



Example of a workstation



Example of an autoradiography of a “blot”

1 | 3

Electrical generators of ionising radiation

Electrical generators of ionising radiation (generally X-rays) are mainly intended for use in non-destructive structural analyses (tomography, diffractometry, etc.), checks on weld bead quality, or material fatigue inspections (aerospace).

The customs service and armed forces also use them to check containers of goods or in explosion radiography programmes. There are also more specific uses based on radiography for restoration of musical instruments or paintings, archaeological study of mummies or analysis of fossils.

Veterinarians also use these appliances for bone radiography and other common diagnosis procedures.

These appliances are also used for industrial gauging purposes (drum filling measurement, etc.) working on the principle of X-ray attenuation.

Unlike equipment used in the medical field, there is no CE marking obligation allowing free circulation of these appliances throughout the European Union.

1 | 4

Particle accelerators

Finally, certain applications require the use of particle accelerators which produce photon or electron beams.

The inventory of particle accelerators in France, whether linear (linacs) or circular (cyclotrons and synchrotrons), comprises about 50 installations which can be used in a wide variety of fields, as presented in table 1 below.

1 | 5

Activities being phased out, unjustified activities, prohibited activities

Various activities are tending to disappear, mainly because of technological progress: this is the case with determining the dew point, level measurements and density measurements, for which techniques based on X-rays or ultrasounds are tending to replace those based on radionuclides. This is also the case with measuring snow height or the position of cable cars using a radionuclide source incorporated into the splices of the support cable.

The manufacture and sale of lightning arresters containing radionuclides was prohibited by the order of 11 October 1983 concerning the ban on the use of radioelements in the manufacture of lightning arresters and on the sale and import of these lightning arresters, applicable as of 1 January 1987, in response to the concerns mentioned in article L. 1333-2 of the Public Health Code, which specifies that “certain activities and certain processes, devices or substances exposing persons to ionising radiation may, owing to the scant benefits they offer or the degree of harm they cause, be prohibited by the regulations or may be regulated”.

No intentional addition of radionuclides in consumer goods and construction products is therefore authorised (articles R. 1333-2 and 3 of the Public Health Code). In this respect, the manufacture, import and trade in irradiated precious stones, which contain residual activity following activation designed to improve their aesthetic quality and sale value, are not authorised.

INDUSTRIES	PROCESSES	PRODUCTS
Chemistry Petrochemistry	Cross-linking Depolymerisation Covalent bonding – Polymerisation	Polyethylene, polypropylene, copolymers, lubricants, alcohol
Coatings Adhesives	Vulcanisation Covalent bonding Polymerisation	Adhesive tapes, coated paper products, ply panels, heat shields, wood-plastic and glass-plastic composites
Electricity	Cross-linking Thermal memory Modification of semiconductors	Constructions, instruments, telephone wires, power cables, insulating tape, shielded cable splices, Zener diodes, etc.
Foods	Disinfection – Pasteurisation Conservation – Sterilisation	Animal feedstuffs, grains, cereals, flour, vegetables, fruit, poultry, meat, fish, shellfish
Health Pharmacy	Sterilisation Modification of polymers	Disposable material, powders, drugs, membranes
Plastics Polymers	Cross-linking Foam manufacturing Thermal memory	Shrink-wrap food packaging, gymnastics appliances, pipes and ducts, moulded packaging, flexible laminated packaging
Environment	Disinfection – Precipitation Organic detoxification Fermentation inhibition DeSOx/DeNOx	Residual sludges for spreading, smoke emission, gases, solvents, water and various effluent, nutrients from sludge or waste
Paper pulp Textiles	Depolymerisation Covalent bonding	Polyethylene, polypropylene, copolymers, lubricants, alcohol
Rubber	Vulcanisation, strength enhancement Controlled vulcanisation	Adhesive tapes, coated paper products, ply panels, heat shields

Table 1: use of particle accelerators

The same applies to accessories such as key-rings, hunting equipment (sighting devices) or equipment for river fishing (floats) fitted with sealed tritium sources.

Case of watches containing tritium

Consideration is being given to the justification for the use of tritiated paint applied to watch faces and hands to make them luminescent or the use of ampoules containing tritium inserted into watch faces or hands. It should be noted that the health impact of watches marked with tritium is very low for their wearers (a few µSv/year) in normal conditions of use and that, for this reason, such watches may be freely purchased in many countries, including in Europe. Discussions are taking place between the ASN and the DGCCRF to obtain a clearer picture of this market and identify the companies active on it. It is worth noting that in France, there are no companies still manufacturing tritium paint.

On this subject, and in the presence of its Swiss counterpart, the ASN met the two leading Swiss companies manufacturing tritiated paint and ampoules. It would appear that tritium paint has been replaced on a massive scale by photoluminescent paint (no radioactivity), but that tritium ampoules, with offer better containment of radioactivity and more persistent luminescence, are still used in numerous applications. The ASN formally reminded these companies of the main requirements of the French regulations, in particular the need for a licence to import any radioactive source from Switzerland.

2 Regulatory provisions concerning industrial and research applications

The provisions concerning the industrial and research applications given in the Public Health Code (articles R. 1333-26 to R. 1333-28) are recalled below.

2 | 1 Licensing procedures for ionising radiation sources used for industrial and research purposes

Table 2 presents the procedures governing the various industrial and research applications, including for veterinary purposes.

Unlike medical applications, industrial and research applications always require licensing, although some of them in certain conditions may be exempted from this licence requirement. The Public Health Code also introduced a licence waiver issued by the Minister for Health for nuclear activities which have already been licensed under the Mining Code, the basic nuclear installations system or that covering installations classified on environmental protection grounds.

<table>
<tr><th>Nature of the nuclear activity</th><th>Procedure and competent authority</th><th>Observations</th></tr>
<tr><td>Manufacture of radioactive sources or devices containing them</td><td rowspan="4">Licensing by the Minister for Health (ASN)(1), unless nuclear activity in licensed ICPE comprising section 1700 above notification threshold: prefectoral licence</td><td></td></tr>
<tr><td>Manufacture of products or devices containing radioactive sources</td><td rowspan="2">Exemption possible if criteria set in article R.1333-27 of the CSP are met(2)</td></tr>
<tr><td>Use of radioactive sources</td></tr>
<tr><td>Irradiation of products, including food products</td><td></td></tr>
<tr><td>Use of electrical generators, including particle accelerators</td><td rowspan="3">Licensing by Minister for Health (ASN)</td><td>Exemption possible if criteria set in article R.1333-27 of the CSP are met(2)</td></tr>
<tr><td>Import or export of radioactive sources or devices containing them</td><td></td></tr>
<tr><td>Distribution of radioactive sources or devices containing them</td><td>Exemption possible if criteria set in article R.1333-27 of the CSP are met(2)</td></tr>
</table>

Table 2: procedures applicable to industrial or research nuclear activities

(1) The licences issued for nuclear activities subject to the Mining Code or the basic nuclear installations system are equivalent to a licence issued under the Public Health Code.

(2) The criteria for exemption from the licensing procedures apply:

– to radionuclides, if the total quantities involved or their concentration per unit of mass are below the thresholds set in the appendix to the Public Health Code (provided that the masses of substances involved do not exceed one ton);

– to electrical generators of ionising radiation, if of a certified type compliant with the standards and if, in normal operation and at any point 0.1 m from their accessible surface, they do not generate an equivalent dose of more than 1 µSv/h, or if an appliance operating with a potential difference of 30 kV or less in the same dose equivalent rate limit conditions.

The maximum validity of the licences is 5 years renewable. The licence which is issued to the head of an installation is personal and non-transferable. Any modification to the licence concerning either its beneficiary, or the installation, or its operating conditions, must be re-examined under article R.1333-36 of the Public Health Code. The licensee must make arrangements to protect, inform and provide radiation protection training for all those likely to be exposed to ionising radiation, specified in articles L. 1333-8 and L. 1333-11 of the Public Health Code.

Finally, any incident or accident likely to be the cause of over-exposure of an individual must be immediately declared to the Prefect of the department and to the ASN. It should be recalled that in 2003, the ASN set up a 24-hour telephone hotline for emergency situations (toll-free number: 0 800 804 135), but which can also be used for any radiological incident occurring in an industrial or research facility using sources of ionising radiation.

Section 3|3 provides details on how to prepare the licence application dossiers mentioned in articles R. 1333-26 and R. 1333-27. A regulation currently under preparation and based on article R. 1333-44, will detail the corresponding procedures.

Particular conditions for the use of radioactive sources

*(the texts marked with * denote the most frequently used)*

- licensing of sealed sources: conditions applicable to the recovery and disposal of expired sources or sources which are no longer used (CPAs)*;
- extension of the licence to use radioactive sealed sources of artificial radioelements beyond the ten-year period stipulated in the CPAs;
- use of natural krypton gas;
- use of gaseous phase leak detectors on underground piping;
- use in hydrology;
- use for measuring air renewal rates;
- use of portable devices*;
- use of adsorbed tritium sources;
- use for ionisation of electron tubes and discharges;
- use for combustion smoke or gas detectors*;
- use of sealed sources for reference, calibration and testing*;
- distribution of laboratory reagents, calibration sources and measuring or analysis instruments;
- use of sources which, in nuclear power reactors are employed as start-up sources, or in fixed radiation protection channels for unit control systems, or in boron meters and power range measurement channel control systems as well as in irradiation specimen capsules.

Table 3: scope of application of the main particular conditions of use for radiation sources

Particular conditions for the use

The CIREA (Interministerial Commission on Artificial Radioelements), which until 2002 was responsible for giving its opinion on issues relating to artificial radioelements had, for activities requiring licensing, set particular conditions of use (CPEs) designed to inform the future licensee of the conditions for applying the regulations in its field of activity. Until such time as a text of at least equivalent scope is published, the CPEs are still in force in accordance with decree 2002-460. Table 3 on the previous page presents the areas in which the main CPEs are applied.

The more commonly used of these CPEs will then be transcribed into regulations, while the others will remain particular technical specifications recalled in the individual licences. This is why, given the scale of the risks involved in the practice of gamma radiography, an order was published in March 2004 to update the conditions for use of gamma radiography appliances and cancel the corresponding CPE.

2 | 2

Radionuclide source management rules

These rules, already presented in chapter 3, point 1|2|4, are of course also applicable to the fields of industry and research. It should be remembered that these rules concern:

- the obligation to obtain a licence prior to any transfer or acquisition of sources;
- preliminary registration of all source movements to the IRSN;
- book keeping by the licensee of detailed accounts for the sources in his possession, and their movements;
- immediate notification to the Prefect and the ASN of any loss or theft of radioactive sources;
- return by the user, at its own expense, to its suppliers - who are then obliged to take them - of sealed sources that have expired, are damaged or are no longer needed.

2 | 3

Licensing procedures

For each nuclear activity mentioned in table 2 above and requiring licensing by the Minister for Health, the corresponding application is examined by the ASN. It must be submitted by the person in charge of the nuclear activity jointly with the head of the establishment or his representative. This dossier should be drawn up on the basis of a form to be collected from the ASN and returned to it, accompanied by all elements requested.

The dossier should establish that radiation protection guarantees are in place and effective and that they were defined taking account of the principles of justification, optimisation and limitation specified in article L. 1333-1 of the Public Health Code. This dossier should therefore comprise elements concerning:

- the justification for the application;
- the conditions of possession and use of the sources;
- the presence of a person with competence in radiation protection;
- the characteristics and performance of appliances containing the sources held and used;
- radiation protection provisions;
- drafting of safety instructions;
- the precautions taken against the risks of theft or fire.

When examining the licensing applications, the ASN may, as it sees fit, call on the expertise of the Institute for Radiation Protection and Nuclear Safety (IRSN) and, if necessary, that of organisations whose competence it recognises in the fields of radionuclide source safety and the safety of electrical generators of radiation.

In 2005, the ASN continued with its actions to promote handling of licensing applications by its regional divisions. The ASN is therefore gradually entrusting the Regional Departments for Nuclear Safety and Radiation Protection (DSNRs) with the examination of certain licences, for example those concerning the possession and use of gammagraphs, gammadensimeters or appliances for detecting lead in paint.

3 INSTALLATIONS INVENTORY AND SOURCE MOVEMENTS

3 | 1

Sources of ionising radiation

3 | 1 | 1

Radionuclides

Tables 4 and 5 specify the number of facilities authorised to use radioactive sources in the applications identified. They illustrate the diversity of these applications.

It should be noted that a given facility may carry out several activities and will therefore appear in the above-mentioned tables 4 and 5 for each of its activities.

Main uses of sealed radioactive sources	2002	2003	2004	2005
Gamma radiography	189	192	147	140
Density measurement and weighing	455	457	337	289
Thickness measurement	229	221	180	156
Dust measurement	96	94	79	70
Thin layer thickness measurement	39	33	23	20
Basis weight measurement	261	271	228	204
Level measurement	467	449	348	289
Humidity and density measurement	363	339	278	269
Logging	10	9	14	13
Elimination of static electricity	26	27	22	21
Smoke detectors	2	2	2	2
Use of neutrons sources	55	55	44	38
Analysis	111	113	87	80
Calibration	846	875	813	806
Teaching	132	148	137	133
Research	19	21	19	19
Chromatography	516	521	477	450
Electron capture detectors	64	69	56	56
X-ray fluorescence analysis	1,037	1,343	1,643	1,848

Table 4: use of sealed radioactive sources

Main uses of unsealed radioactive sources	2002	2003	2004	2005
Research	1,076	1,082	1,047	1,030
Use of tracers	19	21	16	16
Calibration	95	103	92	84
Teaching	25	23	22	19

Table 5: use of unsealed radioactive sources

3 | 1 | 2

Electrical generators of ionising radiation

In the light of changing regulations, the ASN does not yet have sufficiently precise data linking the number of installations and the nature of the applications. However, the obligation to obtain prior licensing for use of this type of appliance, in accordance with the Public Health Code, should in the coming years provide the ASN with this information and thus provide an accurate picture of the inventory of this type of equipment.

Table 6 specifies the number of facilities authorised to use electrical generators of ionising radiation in the listed applications. It illustrates the diversity of these applications.

Main use of electrical generators of ionising radiation	2005
Non-destructive testing (radiography/radioscopy)	33
Cristallography	11
X-ray fluorescence analysis	60
Industrial gauging (level measurement, etc.)	10
Research	2
Calibration	0
Teaching	2

Table 6: use of electrical generators of ionising radiation

3 | 2

Radionuclide manufacturers and suppliers

In the field of radioactive source distribution, it is relatively rare for the supplier, who is also very rarely the manufacturer, to deliver an isolated source. It generally also distributes a range of appliances containing sealed and unsealed radionuclides. The number of companies involved in the distribution of radioactive sources or devices is stable in relation to the previous year. Table 7 shows this trend.

Number of suppliers identified per year			
2002	2003	2004	2005
183	202	182	179

Table 7: supplier licences

3 | 3

Radioactive source users and monitoring

In recent years, there has been a rise in the number of licences issued for the possession and use of sealed sources, primarily due to the growth in the number of devices for detecting lead in paint. It should be noted that a licence can cover the simultaneous use of both sealed and unsealed sources. Table 8 shows a slight rise in users of sealed sources and relative stability in users of unsealed sources.

Number of users identified for each type of source per year							
Sealed radioactive sources				Unsealed radioactive sources			
2002	2003	2004	2005	2002	2003	2004	2005
3,554	3,800	4,180	4,277	758	1,165	1,138	1,110

Table 8: users per type of source

3 | 4

Source inventory

3 | 4 | 1

The inventory of radioactive sources

Movements of radioactive sources around the country are illustrated in table 9.

Periodic checks are carried out on the inventory of sources allocated to a user and on their movements, in particular by comparing them with the data in the reports from the approved organisations leading to on-site checks.

Sealed source movements				
Sealed sources	2002	2003	2004	2005
in circ. as of 31.12	26,018	24,508	19,478	17,428
distributed in	3,195	2,243	2,067	1,756
recovered in	2,365	2,682	1,534	1,297

Table 9: sealed source movements (IRSN data)

3 | 4 | 2

Inventory of electrical generators of ionising radiation

The French inventory of equipment intended for industrial or research activities is today poorly known, insofar as past regulations, based on a simple notification, were poorly applied. Furthermore, unlike the system put in place for sealed radioactive sources, there was no centralised inventory system supplied with data about transfers between suppliers and users.

However, the creation of a licensing system and the increasing number of field inspections are likely gradually to improve the data available on the generator inventory.

The number of installations using electrical generators of ionising radiation for industrial, research or veterinary purposes is currently estimated at several thousand.

4 PRIORITIES IMPLEMENTED DURING THE YEAR

4 | 1

General actions

In 2005, and in addition to its regulatory preparation work, the ASN initiated or continued with several actions of a more general nature designed to improve awareness of the applicable regulations, rationalise the scope of certain licences concerning a given facility, or promote the drafting of guides of good practice by the professionals.

These informative actions include ASN participation in:
- the "National research laboratories radiation protection prevention days" organised by the INSERM (national health and medical research institute);
- the days organised by the COFREND (French confederation of non-destructive testing), specifically dealing with gamma radiography;
- the SFRP (French radiation protection society) days dealing with radioactive sources;
- several meetings held in universities.

These actions enable the ASN to recall the main applicable regulatory requirements, to specify what they expect and to stress practical aspects for facilitating the smooth running of the licensing process. They are also the opportunity for the ASN to obtain direct feedback from the users concerning any constraints and difficulties they are experiencing. With respect to rationalisation of the scope of licensing, we would also mention:
- the continued process to combine the licences of the Pasteur Institute in Paris, with a view to improved internal supervision of the Institute;
- combination of the licences (in particular for gamma radiography) of several companies with a number of facilities in France and operating with internal rules common to the various sites.

When the company organisation so allows, this approach is designed to reduce the number of licences covering all the company's activities and thus shift overall responsibility to the head of the facility.

Finally, concerning the encouragement given to professionals to define guides of good practice for radiation protection in their daily activities, the ASN in July 2005 suggested to the COFREND that consideration be given to justification of gamma radiography work and production of a document detailing the best practices to be observed, both by the client and by the gamma radiography contractors. Gamma radiography is an area in which the radiation protection stakes are high, as incorrect use of the appliances or loss of a gammagraph source are likely to have serious health consequences. This hazard is indeed illustrated by the accident which occurred on 15 December 2005 in Chile, in which a Chilean worker was seriously irradiated and is currently being treated at the Percy hospital in France. In a letter dated 8 September 2005, the COFREND agreed in principle to such actions.

4 | 2

Suppliers

In 2005, the ASN carried on with priority action initiated in 2003 about the suppliers of radionuclide sources or appliances containing them and used for industrial or research purposes. These companies have considerable responsibility for the safety of source movements, their traceability, the recovery and the disposal of used or unwanted sources. It is therefore important that their situation with regard to radiation protection rules be transparent and unambiguous and that their activities be duly covered by the licence specified in article R. 1333-27 of the Public Health Code.

During the course of 2005, 35 licences were issued to suppliers and 11 licences were revoked. Several dozen dossiers are also being investigated by the ASN.

In this respect, these dossier investigations can last a long time, given the combination of various negative factors, including:

- the problem in identifying the right people to talk to and then obtaining pertinent data about the sources and appliances;
- the complexity of the radiation protection analyses for appliances and radionuclide sources;
- obtaining specific guarantees to ensure effective recovery of used or unwanted sealed sources.

However, the extensive work currently under way on this type of dossier will ease later examination subsequently when renewing licences or when licence modifications are requested.

4 | 3

Users

Examination by the ASN of about 1300 application dossiers for possession and use of radionuclides led to 351 new licences being notified and 209 licences being revoked. About 800 dossiers concerning an industrial or research activity are currently being examined by the ASN. Table 10 shows licence issue and revocation trends over the past four years.

Once the licence is obtained, the licensee may procure sources. To do this, it collects supply request forms from the IRSN, enabling the institute to check that the orders are in accordance with the licences of both user and supplier, it being one of the institute's duties to update the inventory of ionising radiation sources. If the order is correct, the movement is then recorded by the IRSN, which notifies the interested parties that delivery may take place.

2005 saw a fall in the number of dossiers being processed and of notifications issued, chiefly concerning new licences, with stabilisation of renewals and updates.

Electrical generators of ionising radiation

The ASN has begun investigation of applications for licences to possess and use electrical generators, it being recalled that in the previous regulations, these installations simply required notification.

A number of problems were raised during these investigations. In particular, X-ray generators are working equipment according to the Labour Code. Therefore, they have to comply with construction standard NFC 74-100 (construction and tests) setting technical requirements to be met by the generators and which were made mandatory by the order of 2 September 1991, and standards NFC 15-160 (general rules) and NFC 15-164 (rules specific to industrial radiology devices) referred to by the order of 30 August 1991 concerning installation conditions for these appliances. These requirements were not abrogated with the changing regulations, which modified the annual exposure limits for workers and members of the public and which have switched these appliances from the notification category to that requiring licensing.

The ASN has begun discussions with the Ministry for Labour with a view to changing these regulations and encouraged the UTE (technical union of electricity) to begin to update the above-mentioned standards. The UTE therefore initiated a revision of the NF-C 15-160 standards and the associated specific standards.

However, in 2005, the ASN granted 119 licences for the use of electrical X-rays generators.

The case of sources of ionising radiation used in BNIs

Radioactive source "user" licensing trends				
Years	2002	2003	2004	2005
New licences	407	485	560	351
Renewals – update	1,127	1,165	707	739
Revocations	168	200	209	209

Table 10: radioactive source "user" licensing trends

Article R. 1333-26 of the Public Health Code states that the licence (authorisation decree) issued for a basic nuclear installation (BNI) is equivalent to a licence to possess and use ionising radiation sources, unless these sources are intended for medical applications. This simplification applies to the sources needed for BNI operation, with the other sources being subject to licensing under the terms of the Public Health Code.

In order to implement these measures, the ASN asked the BNI operators to supply it with a list of sources in their possession, differentiating between those needed for operation of the installations from the other sources.

The ASN also continued to press the CEA to regularise its situation with respect to the Public Health Code, by obtaining licences for the possession and use of the sources of ionising radiation it uses in its various establishments, in place of the waiver from which it previously benefited and which gave it a permanent licence. This approach led the ASN in 2004 and 2005 to send the CEA a list of the licences per facility for possession and use of radioactive sources. The regularisation work is continuing with respect to electrical generators of ionising radiation.

5 CHECKS ON RADIATION SOURCES AND INSTALLATIONS

5 | 1

Checks conducted by the ASN

The checks applied to radiation sources depend on the nature of the source and the stage of production and use reached. They are presented in chapter 4, paragraph 2|2|3.

The ASN pays particularly close attention to the use of gamma radiography appliances. In this respect, the ASN sent out a circular letter to the firms concerned on 26 April 2004, urging them to abide by the main regulatory requirements in force, following the discovery of numerous inadequacies in application of good radiation protection practices, and even some serious breaches of the regulatory requirements stipulated in the Public Health, Labour and Environment Codes. This circular letter was the subject of an information note published on the ASN web site (www.asn.gouv.fr). The ASN made inspection of establishments using gamma radiography appliances once of its priority inspection topics for 2004 and 2005. The main inadequacies concern prior evaluation and optimisation of doses, as well as the conditions for carrying out gamma radiography operations on the worksites. The ASN clearly informed the gamma radiography professionals that they would need to exert greater diligence in the operation and transport of gammagraphs.

5 | 2

Sealed source retirement

According to the Public Health Code (articles L. 1333-7 and R. 1333-52), all users are required to have the suppliers recover the sealed sources they supplied, as soon as the user no longer needs them, and in any case no later than ten years following the date the first approval was marked on the source supply request.

The supplier is required to recover the source whenever requested by the user. It must also set up a security deposit to cover the consequences should it default and should another party or the ANDRA be required to step in to take its place. Finally, in accordance with article R. 1333-52, the supplier is required to declare any source not returned to it within the specified time.

The organisation recovering the source is required to send the user a notice of recovery mentioning the characteristics of the source and the references of its possession authorisation form. Presentation of this document is proof that the user no longer has responsibility for use of the source. On the basis of this document, the source is removed from the user's inventory in the national source inventory managed by the IRSN, but a trace of it is kept in an "archives" file.

When renewal applications are examined, in the event of closure of the company or during occasional periodic inspections, the ASN with the assistance of the IRSN systematically checks the situation and the future disposal of the sealed sources.

In order to further strengthen the guaranteed recovery of radionuclide sources and make the system easier to use, the suppliers set up a non-profit association in 1996, called Ressources, the purpose of which is to create a guarantee fund from which to reimburse ANDRA or any other approved organisation for the cost involved in recovering sources from the user, either because the supplier normally responsible for their recovery has defaulted, or because no supplier can be identified in the case of stray sources.

The Ressources association, which comprises about sixty members, has become the profession's main interface, in that it covers nearly 95% of the market for this activity.

As part of the national radioactive waste management plan (see chapter 16), solutions for the used source disposal are being studied because there is still no disposal channel for them. A draft regulation stipulating the disposal (decommissioning) method for sources is being prepared accordingly. The ASN also gave its agreement in principle for disposal in the Aube repository of sources with a half-life equal to or less than that of caesium isotope 137 (or about 30 years).

5 | 3

The impact of industrial and research installations

The ASN currently has little data to enable it to assess the impact of the uses of sources of ionising radiation for industrial and research purposes, except with respect to worker exposure.

According to the existing data collected by the IRSN concerning exposure of workers active in industry or research, these sectors respectively comprise 36,787 and 11,147 exposed persons who are subject to dosimetric monitoring. In industry, 90% of those monitored (IRSN 2004 figures) received an effective dose over one year of less than 1 mSv and the annual limit of 20 mSv was found to have been exceeded 10 times, while no overshoot was detected in the research sector where nearly all (99.8%) of the staff monitored were not exposed to an effective annual dose of more than 1 mSv. It is worth noting a slight drop in the average dose received by industrial workers, which is about

250 microsieverts, and a relative drop in the number of industrial workers who received an annual dose in excess of 1 mSv (10% above this value in 2004 as opposed to 20% in 2003). The number of occasions on which the 20 mSv limit was exceeded fell significantly, from 40 in 2003 to 10 in 2004.

The impact of non-BNI industrial or research applications on the environment and the general public has not been the subject of any specific monitoring, except special cases. The available information concerns general environmental monitoring as performed by the IRSN, in particular ambient gamma radiation measurement, which on the whole shows no significant level of exposure above variations in background natural radioactivity, except occasionally and momentarily when gamma radiography is detected by the monitoring and alarm system.

The gradual expansion of ASN radiation protection supervision, allied with environmental monitoring targeted on certain installations and the use of appropriate computer models, should provide a more accurate picture of the impact of industrial and research applications. These actions will have to be incorporated into multi-year programmes.

6 SIGNIFICANT EVENTS

The incidents declared primarily concern loss or theft of radioactive sources or portable devices containing them (lead detection, etc.), inappropriate use or total or partial accidental destruction of a radionuclide source.

For the year 2005, there were about twenty, including:
- 15 losses or thefts of sealed sources from their place of use;
- 2 potential over-exposure incidents.

7 OUTLOOK

With regard to supervision of the applications of ionising radiation in industry and research, the ASN continued to define its priorities in order to optimise use of the means available to it. At the same time, the gradual growth in the ASN's resources continued so that within a few years it will be in a position to carry out all of its duties.

The action taken in previous years was also carried on and supplemented by:
- continuation of the work to update the licences issued to the manufacturers and suppliers of radioactive sources and the actions undertaken concerning the research sector;
- application of the licensing system to electrical generators of ionising radiation used in industry and research;
- visits carried out in particular to the users and those in possession of gammagraphs and gammadensity meters;
- rationalisation of licences within the establishments whenever possible, with continuation of this particular objective, which will be made easier by the planned changes to the Public Health Code.