NON-MEDICAL USES OF IONISING RADIATION

CHAPTER 10

Industry, research, and also a large number of other sectors have for a long time been using sources of ionising radiation for a wide variety of applications and in a large number of locations. The purpose of the radiation protection regulations is to check that, despite this great diversity, the safety of workers, the public and the environment is ensured. This safety includes source management, supervision of the conditions in which sources are held, used and disposed of, from fabrication to end-of-life. It also involves increasing the monitoring of the main stakeholders, the source manufacturers and suppliers, and enhancing their accountability.

The regulatory framework governing nuclear activities in France has undergone major changes and been tightened over the last few years. It falls within the scope of the Labour Code and the Public Health Code, and orients ASN's actions.

The radiation sources used are either radionuclides, primarily artificial, in sealed or unsealed sources, or electrical devices generating ionising radiation. The applications presented in this chapter concern non-medical activities (the medical activities are presented in chapter 9) and activities which are not carried out in basic nuclear installations (the BNIs are presented in chapters 12, 13 and 14). However, all the other applications are concerned. The main activity sectors are presented below.

1 NON-MEDICAL ACTIVITIES USING IONISING RADIATION

1|1 Sealed radioactive sources

The main uses of sealed radioactive sources (sources whose structure or packaging, in normal use, prevents any dispersal of radioactive materials into the environment) are as follows.

1|1|1 Industrial irradiation

This is used for sterilising medical equipment, pharmaceutical or cosmetic products and for conservation of foodstuffs.

Irradiation is also a means of voluntarily modifying the properties of materials, for example, to harden polymers.

These consumer product irradiation techniques may be authorised because once the products are treated, they show no signs of added artificial radioactivity. Industrial irradiators often use cobalt 60 sources, whose total activity can be very high and exceed 250,000 terabecquerels (TBq). Some of these installations are classified as BNIs (see chapter 14).

1|1|2 Non-destructive testing

Gamma radiography is a non-destructive testing technique that uses radioactive sources to detect homogeneity defects in metals, and particularly in weld beads. This technique primarily uses sources of iridium 192, cobalt 60 and, more recently, selenium 75, the activity level of which does not exceed about twenty terabecquerels. Gamma radiography is usually performed using a mobile device which can be moved from one worksite to another and consists primarily of:

– a source applicator, used as a storage container when the source is not in use;
– an ejector tube, end-piece and remote-control for moving the source between the applicator and the object to be inspected, while protecting the operator who can thus remain at a distance from the source.

Gamma radiography projector - CEGELEC - and accessories (remote control, ejection tube, irradiation endpiece)

– a radioactive source inserted into a source-holder.

Gamma radiography devices mainly use high-activity sources that present substantial operator risks. As such, it is an activity with high radiation protection implications that figures among ASN's inspection priorities.

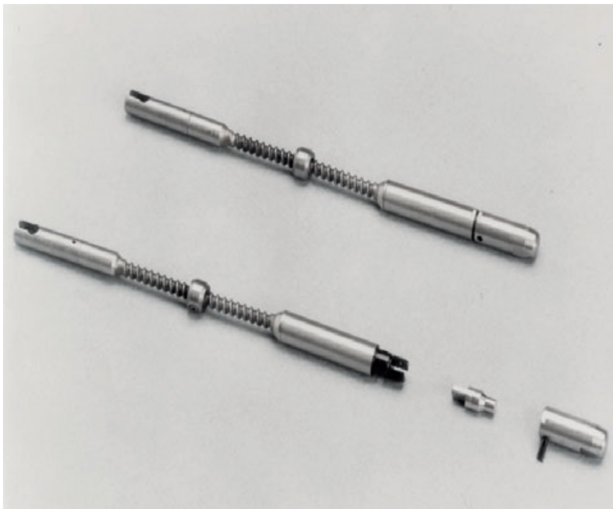
1|1|3 Verification of physical parameters

The operating principle of these devices is the attenuation of the signal emitted: the difference between the emitted signal and the received signal can be used to assess the information looked for.

The radionuclides most frequently used are krypton 85, caesium 137, americium 241, cobalt 60 and prometheum 147. The source activity levels are between a few kBq and a few GBq.

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



Source and source-holder assembly contained in a gamma radiography device

the filter, which enables this amount to be determined. The most commonly used sources are carbon 14 (activity level: 3.5 MBq) or prometheum 147 (activity level: 9 MBq). These measurements are particularly used for air quality monitoring by verifying the dust content of discharges from plants;
– basis weight measurement: a beta radiation beam passes through the paper and is then received by a detector. The signal attenuation on this detector gives 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 indicates the level of filling of the container and automatically triggers certain operations (stop/continue filling, alarm, etc.). The radionuclides used depend on the characteristics of the container and the content. As applicable, americium 241 (activity level:1.7 GBq), caesium 137 - barium 137m (activity level: 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 level: 2 GBq), caesium 137-barium 137m (activity level: 100 MBq) or cobalt 60 (30 GBq);
– soil density and humidity measurement (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 subsoil to be examined by inserting a measurement probe comprising a source of cobalt 60, caesium 137, americium 141-beryllium or californium 252.

1|1|4 Neutron activation

Neutron analysis is based on the following principle: a beam of neutrons bombards a volume of material and excites its atoms. The number, the energy and the direction of the gamma photons emitted in response to neutron bombardment are analysed. The information collected enables the concentration of atoms in the analysed material to be determined.

Some cement works in France and abroad use neutron analysers for on-line chemical analysis of the cement constituents. Of the thirty or so cement works in France, three use this technology. As this technology can activate the analysed material, it requires the granting of a waiver as provided for by article R.1333-4 of the Public Health Code. In 2010, the Government asked ASN to examine a waiver application concerning the utilisation of a neutron analysis device in a cement works, and to give its opinion.

Reminder: article R.1333-3 prohibits the use of materials and waste originating from a nuclear activity for the manufacture of consumer goods and construction products, if they are or could be contaminated by radionuclides, including by activation, as a result of this activity.

Article R.1333-4 of the Public Health Code makes provision for a waiver from this prohibition if the addition of radionuclides is justified by the benefits it brings in relation to the health risks it can represent. In this respect, the article holds that this waiver is established by an order of the ministers in charge of health and, depending on the case, either the minister in charge of consumption or the minister in charge of construction, after obtaining the opinion of the ASN and HCSP (French High Public Health Council).

1|1|5 Other common applications

Sealed sources can also be used for:
– eliminating static electricity;
– calibrating radioactivity measurement devices (radiation metrology);
– practical teaching work concerning radioactivity phenomena;
– electron capture detectors using sources of nickel 63 in gaseous phase chromatographs. This technique can be used to detect and dose various elements;
– ion mobility spectrometry used in devices that are often portable and used to detect explosives, drugs or toxic products;
– detection using X-ray fluorescence devices. This technique is particularly useful in detecting lead in paint. The portable devices used today contain sources of cadmium 109 (half-life 464 days) or cobalt 57 (half-life of 270 days). The activity of these sources can range from 400 MBq to 1,500 MBq. This activity, which represents a large number of radioactive sources in France (nearly 4,000 sources), results from a legislative measure to prevent lead poisoning in children, which obliges a verification of the lead concentration in the paintwork of any residential building built before 1 January 1949, if it is to be sold or to undergo works significantly affecting the surface coatings in the common parts of the building.

Graph 1 specifies the number of facilities authorised to use sealed radioactive sources for the applications identified. It illustrates the diversity of these applications and how they evolved from 2006 to 2010.

It should be noted that a given facility may carry out several activities and therefore appears in graph 1 and the following graphs for each activity.

1|2 Unsealed radioactive sources

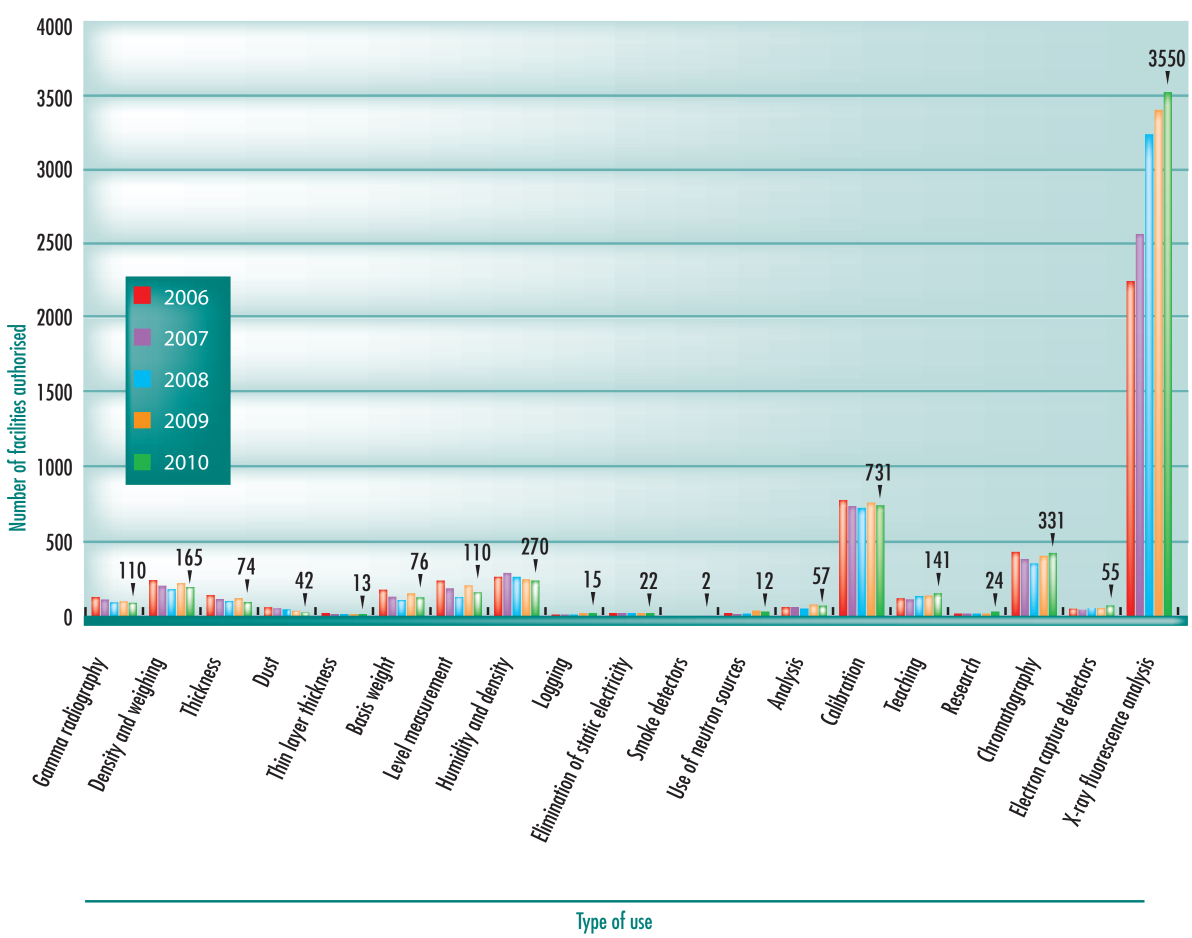
The main radionuclides used in the form of unsealed sources are phosphorus 32 or 33, carbon 14, sulphur 35, chromium 51, iodine 125 and tritium. They are used as tracers for calibration and teaching. Using radioactive tracers incorporated into molecules is common practice in biological research. They 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 number of facilities authorised to use unsealed sources stands at 961.

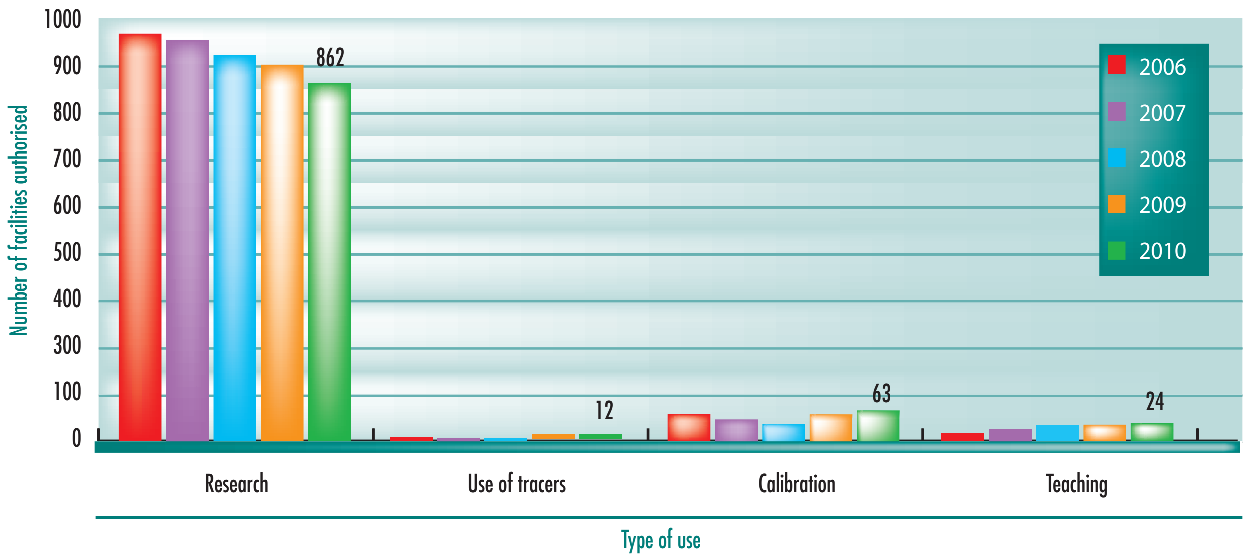
Graph 2 specifies the number of facilities authorised to use unsealed radioactive sources in the applications identified from 2006 to 2010.

Device for detecting lead in paint

Graph 1: use of sealed radioactive sources



Graph 2: Use of unsealed radioactive sources



1|3 Electrical devices emitting ionising radiation

1|3|1 Industrial applications

The electrical devices that emit ionising radiation are primarily X-ray generators. Like devices containing radioactive sources, they are put to a very wide variety of uses in industry, including non-destructive structural analyses (analysis techniques such as computer tomography, diffractometry. (also known as radiocristallography diffractometry- also know as radiocrystal- etc.), inspecting the quality of weld beads or inspecting materials for fatigue (particularly in aeronautics).

The increasing number of types of device available on the market can be explained more particularly by the fact that when possible, they replace devices containing radioactive sources. The advantages of this technology are significant with regard to radiation protection, given the total absence of ionising radiation when the equipment is not in use. When in use however, the exposure levels are comparable with those emitted from devices containing radioactive sources.

The applications of these devices, which work using the principle of X-ray attenuation, include use as industrial gauges (measurement of drum filling, thickness measurement, etc.), inspection of goods containers or luggage and also the detection of foreign bodies in foodstuffs.

Radiography for checking the quality of weld beads or for the fatigue inspection of materials

These are fixed or worksite devices that use directional or panoramic beams. These devices can also be put to more specific uses, such as radiography for restoration of musical instruments or paintings, archaeological study of mummies or analysis of fossils.

Baggage inspection

Ionising radiation are used constantly in security screening checks, whether for the systematic verification of baggage or to determine the content of suspect packages. The smallest and most widely used devices are installed at the filtering checkpoints in airports, in museums, at the entrance to certain buildings, etc.

The devices with the largest inspection tunnel areas are used in the airports for screening air freight, large baggage items and hold baggage in airports. Computer tomography scanners complete this range of appliances.

The irradiation zone inside these appliances is sometime delimited by doors, but most often by one or more lead curtains.

X-ray body scanners

This particular use is given for information only, since pursuant to the article L. 1333-11 of the Public Health Code, the use of X-ray scanners on people in security checks is prohibited in France. Image-generating technologies based on millimetre waves, which are not ionising, are currently being experimented in France.

Various technologies using X-rays do however exist: backscatter of X-rays and transmission of X-rays.
– The backscatter X-ray body scanner produces a superficial image of the scanned person comparable to that obtained with a millimetre wave scanner. It does not detect materials inside the body. The screened person is exposed to 0.1 microsievert/scan (µSv/scan). This technology is very widely used in the United Kingdom and the USA.
– The transmission X-ray body scanner gives an internal image of the screened person comparable to that obtained in medical examinations. This technique can detect materials hidden on and inside the body of a person. The screened person's

X-ray baggage scanner 620XR

exposure varies, according to the manufacturers' information, from 0.25 µSv/scan (whole body dose) to 6 µSv/scan (utilisation in the South African diamond mines).

There are also appliances for screening specific parts of the body: limbs (to check for weapons hidden in an artificial limb), feet and shoes.

Inspection of foodstuffs

In the last few years the use of appliances similar to baggage screening systems for detecting foreign bodies in food products has developed.

X-ray diffraction analysis

X-ray diffraction appliances, which are self-shielded, are being increasingly used by research laboratories. Experimental devices used for X-ray diffraction analysis can however be built by experimenters themselves with parts obtained from various suppliers (goniometer, sample holder, tube, detector, high-voltage generator, control console, etc.).

X-ray fluorescence analysis

These portable X-ray fluorescence devices are intended for the analysis of metals and alloys.

Measuring parameters

These appliances, which operate on the principle of X-ray attenuation, are used as industrial gauges for measuring fluid levels in cylinders or drums, for detecting leaks, for measuring thicknesses or density, etc.

Irradiation treatment

More generally used for performing irradiations, the self-protected appliances exist in several models that sometimes differ only in the size of the self-shielded chamber, while the characteristics of the X-ray generator remain the same.

1|3|2 Veterinary radiodiagnostics

Veterinary surgeons also use these devices for normal radiodiagnostic purposes. More recently, tomography devices have become more common in veterinary applications.

The veterinary care given to domestic animals requires the use of veterinary radiodiagnostic appliances at fixed sites only, and intra-oral radiography devices. The treatment of horses, however, requires more powerful devices installed in specific premises (radiography of the pelvis, for example) and portable X-ray generators, used inside premises – dedicated or not – or externally.

The appliances used in the veterinary sector sometimes come from the medical sector, but the profession is increasingly using appliances developed specifically for its needs.

Unlike electrical generators used for medical applications, there is no CE marking obligation for these devices.

Graph 3 specifies the number of facilities authorised to use electrical generators of ionising radiation in the listed applications. It illustrates the diversity of these applications and how they evolved from 2006 to 2010. This evolution is closely related to the regulatory changes introduced in 2002 and later in 2007, which created a new licensing or notification regime for use of these devices. The situation of the professionals concerned has now begun to be brought into compliance in many activity sectors, but a large number of users have not yet taken any action.

1|4 Particle accelerators

The Public Health Code defines an accelerator as a device or installation in which particles undergo acceleration, emitting ionising radiation at an energy level in excess of 1 megaelectronvolt (MeV).

Use of this type of device is subject to the notification or licensing regime specified in articles L.1333-4 and R.1333-17 of the Public Health Code. When they meet the characteristics specified in article 3 of decree 2007-830 of 11 May 2007 concerning the list of BNIs, these facilities are listed as BNIs.

Certain applications require the use of particle accelerators which produce photon or electron beams, as applicable. The inventory of particle accelerators in France, whether linear (linacs) or circular (cyclotrons and synchrotrons), comprises about 50 identified installations (except for BNIs) which can be used in a wide variety of fields:
- research, which sometimes requires the coupling of several machines (accelerator, implanter, etc.);
- radiography (fixed or mobile accelerator);
- radioscopy of lorries and containers during customs checks (fixed-site or mobile accelerators);
- modification of material properties;
- sterilisation ;
- conservation of foodstuffs;
- etc.

Veterinary radiographic examination

A number of research facilities produce synchrotron radiation, such as the ESRF (European Synchrotron Radiation Facility) in Grenoble, and the Soleil synchrotron in Gif-sur-Yvette (maximum characteristics of the electron beam: 2.75 gigaelectronvolt (GeV), 500 mA).

1|5 Electrical devices emitting IONISING RADIATION

This category covers all the electrical devices emitting ionising radiation other than those mentioned above and not excluded by the license and notification exemption criteria set out in article R. 1333-18 of the Public Health Code.

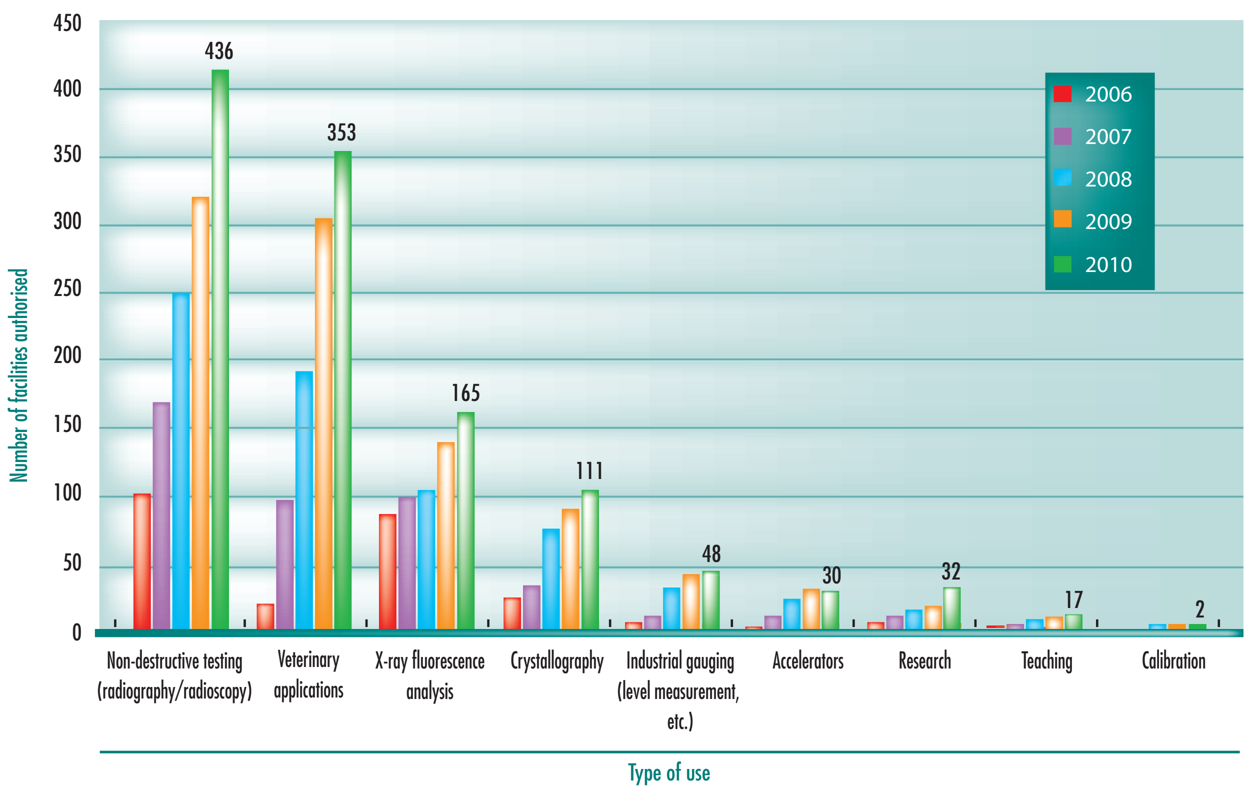
This category includes the other accelerators generating ionising radiation (not covered by the Public Health Code or the BNIs), ion implanters, electron-beam welding equipment, klystrons, certain lasers, certain electrical devices (example of high-voltage fuse tests).

More recently, particle accelerator imaging systems have been used in France to combat fraud and large-scale international trafficking. This technology, which is felt by the operators to be effective, must however be used under certain conditions in order to comply with the radiation protection rules applicable to workers and the public, in particular:

– a ban on activation of construction products, consumer goods and foodstuffs as specified by article R.1333-4 of the Public Health Code, ensuring that the maximum energy of the particles emitted by the accelerators used rules out all risk of activation of the materials being verified,
– a ban on the use of ionising radiation on the human body for purposes other than medical.

One of ASN's concerns is also to ensure that the imaging systems using ionising radiation, which are regularly used to inspect transport vehicles, do not lead to accidental exposure of

Graph 3: Use of electrical devices emitting ionising radiation



Mobile accelerators used for inspecting vehicle loads

Diagram of the inspection area

individuals. Procedures must be established to ensure that the driver is kept away from the vehicle during irradiation, and prior checks must be made to ensure there are no illegal immigrants inside the vehicles before they pass through the scanning facility (see point 3|2). France does not use ionising radiation emitting devices to detect the presence of illegal immigrants in transport vehicles.

2 REGULATING NON-MEDICAL ACTIVITIES

The provisions of the Public Health Code relating specifically to the industrial and research applications provided for in the Public Health Code are specified in this section. The general rules are detailed in chapter 3 of this report.

2|1 Licenses and notifications in the non-medical sector

2|1|1 Authorities regulating ionising radiation sources in France, and the other applicable regulations

The licensing system applies equally well to companies or facilities which have radionuclides on-site and to those which trade in them without directly possessing them.

In application of the Public Health Code, ASN is the authority that grants the licenses and receives the notifications, in accordance with the system applicable to the nuclear activity concerned.

The Health Code does however provide for a series of waivers. The notification or licensing obligation does not apply to installations licensed under another system:

– for the radioactive sources held, manufactured and/or used in installations licensed under the mining system (article 83 of the Mining Code) or in installations classified on environmental protection grounds (ICPE) which come under articles L. 511-1 to L. 517-2 of the Environment Code, and have a licensing system, the *préfet*[1] is the authority responsible for ensuring that these licenses contain instructions relative to the radiation protection of the nuclear activities carried out on the site;
– for installations and activities relating to national defence, ASND (Defence Nuclear Safety Authority) is responsible for regulating radiation protection aspects;
– for installations licensed in accordance with the system for basic nuclear installations (BNIs) under the act relative to nuclear transparency and security, ASN regulates the sources necessary for the functioning of these installations (radioactive sources and electrical devices emitting ionising radiation). Holding and using other sources within the bounds of the BNI remain subject to licensing pursuant to article R.1333-17 of the Public Health Code.

In no way do these waivers exempt the beneficiary from the need to comply with the requirements of the Public Health Code, in particular those concerning the acquisition and transfer of sources.

The distribution, importing and exporting of radioactive sources are not concerned by these waivers, and come under the authority of ASN.

ASN has reminded all licensees that call upon contractors that if these contractors have to use sources of ionising radiation, including if supplied by the licensees, they must hold a license issued by ASN pursuant to article R. 1333-17 and following of the Public Health Code.

These actions led to the drafting of a guide by the licensees for their contractors to help them in their dealings with ASN.

Graph 4 gives a breakdown of the sealed radioactive sources held on French territory according to the authorities regulating this possession.

Nuclear materials are not included in this table in that the license for import, export, production, possession, transfer, utilisation and transport, covered by article L. 1333-2 of the Defence Code, is issued by the Minister of Defence with regard to nuclear materials intended for defence purposes and by the minister responsible for energy for materials intended for all other purposes.

2 | 1 | 2 Licensing and notification frameworks for ionising radiation sources used for non-medical purposes

Applications relating to the holding and use of ionising radiation sources are entirely reviewed by the regional divisions of ASN. The reviewing of supplier licenses is kept at national level.

The project conducted in 2008 and 2009 to revise all the forms and manuals with a view to simplification, grading of risks and harmonisation was continued, resulting in 2010 in an approved ASN decision defining the content of the files to enclose with the license applications (decision 2010-DC-0192). The new forms integrating the provisions of this decision are currently being published.

Furthermore, to achieve a better balance in the sectors of activity subject to notification or licensing, and therefore better adapt the regulatory requirements to the radiation protection implications, ASN continued its work on the introduction of a notification system in the non-medical sector. This led to the publication of several approved decisions (see chapter 3) defining on the one hand the scope of application of this new system and on the other, its implementation procedures. The following are concerned:

- veterinary radiodiagnostic devices (fixed only) meeting one of the following conditions:
  - the emission beam is directional and vertical, except for all tomography devices;.
  - the device is used for intra-oral radiography (ASN decision 2009-DC-0146 of 16 July 2009, amended by decision 2009-DC-0162 of 20 October 2009).
- electrical devices emitting ionising radiation, for which the equivalent dose rate at 10 cm from all accessible surfaces in normal conditions of use and as a result of their design, is less than 10 µSv.h-1.

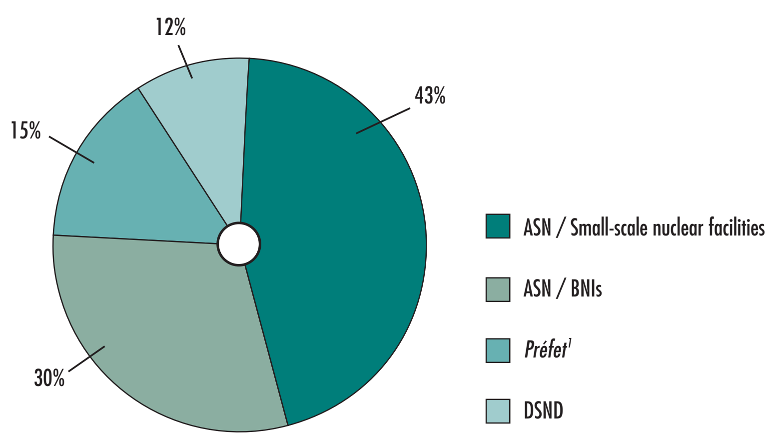
ASN also drew up a notification form to facilitate implementation of decision 2009-DC-0148 detailing the information to be enclosed with the notifications. This form has been designed so as to simplify its use and processing. No document has to be added to the notification form if the devices declared meet the requirements specified in ASN's decisions and are eligible for this system.

2 | 1 | 3 Integration of the fundamental radiation protection principles in the licensing procedures

ASN verifies application of the three major principles governing radiation protection and which are written in the Public Health Code (article L. 1333-1), namely justification, optimisation of exposure and limiting of doses.

With regard to the monitoring of non-medical activities, ASN is particularly attentive to its inspection duties where radioactive source suppliers are concerned, because they play an important role in the marketing of new devices and the optimising of radiation protection from the equipment design stage.

Graph 4: Breakdown of sealed radioactive sources held in France according to the authority regulating their possession



1. In a *département*, representative of the State appointed by the President.

The Public Health Code (CSP) stipulates that "*a nuclear activity or intervention may only be undertaken or carried out if justified by the advantages it procures, particularly in health, social, economic or scientific terms, with respect to the risks inherent in the exposure to ionising radiation to which the individuals are likely to be subjected*".

Assessment of the expected benefit of a nuclear activity and the corresponding health drawbacks may lead to prohibition of an activity for which the benefit would not seem to outweigh the risk. Either prohibition is declared generically, or the license required on account of radiation protection will not be granted.

For existing activities, justification is reassessed when license renewal applications are made if current know-how and technology so warrants.

On this subject of justification, ASN has initiated discussions with its European counterparts concerning the issues involved in implementing this principle arising from directive 96/29 of 13 May 1996. The particular aim is to harmonise practices with the other member countries, while preserving the way France applies the justification principle.

Furthermore, though application of the dose limiting principle is precisely transcribed in the regulatory texts, optimisation is a notion that must be assessed according to the technical and economic context, and its integration must primarily be the concern of the licensees. ASN encourages strong stakeholder involvement in this area, and implements an awareness-raising policy. As part of its duties, ASN checks compliance with the optimisation principle at several levels:
– when reviewing the files:
  • when new products or devices are put onto the market, and when renewing their licenses;
  • before the licensee exercises an activity that is subject to licensing;
  • when the licensee gives notification of a modification in its activity or its installation;
– during on-site visits and inspections;
– by collating experience feedback from investigations following significant radiation protection event notifications.

2|1|4 Statistics for the year 2010

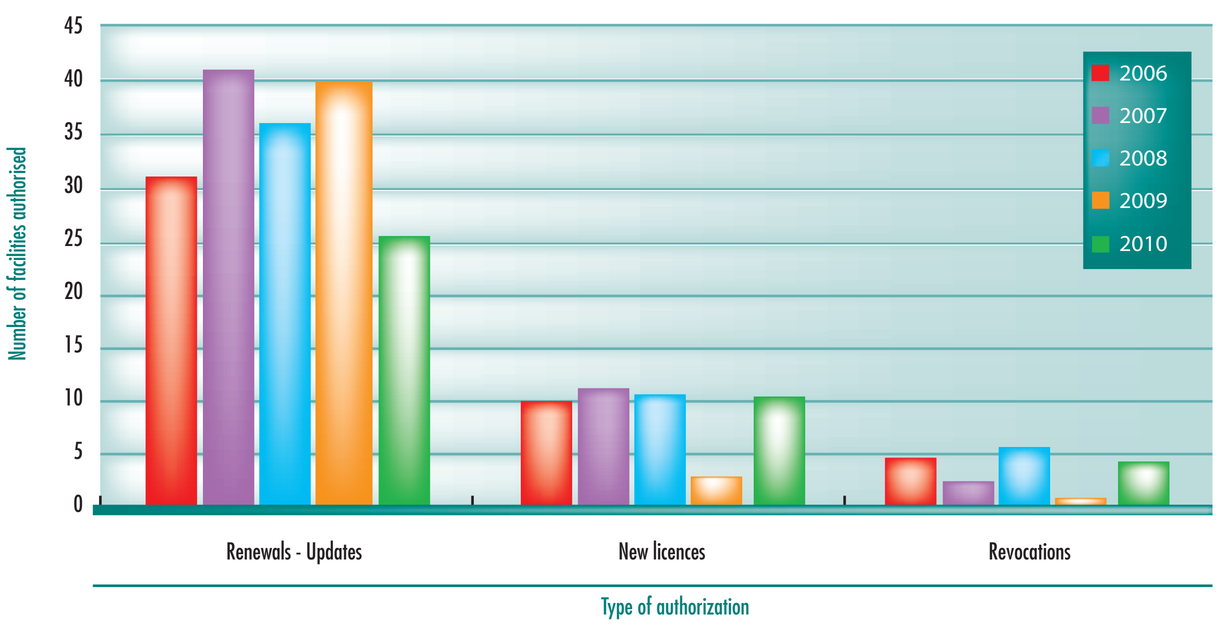
Suppliers

ASN monitoring of the suppliers of radionuclide sources or of devices containing such sources used for non-medical purposes is essential to ensure the security of source movements, their traceability and the recovery and disposal of used or end-of-life sources. Source suppliers must also play a teaching role with respect to users. It is important that their situation with regard to radiation protection rules be satisfactory and that their activities be duly covered by the license specified in article R. 1333-17 of the Public Health Code.

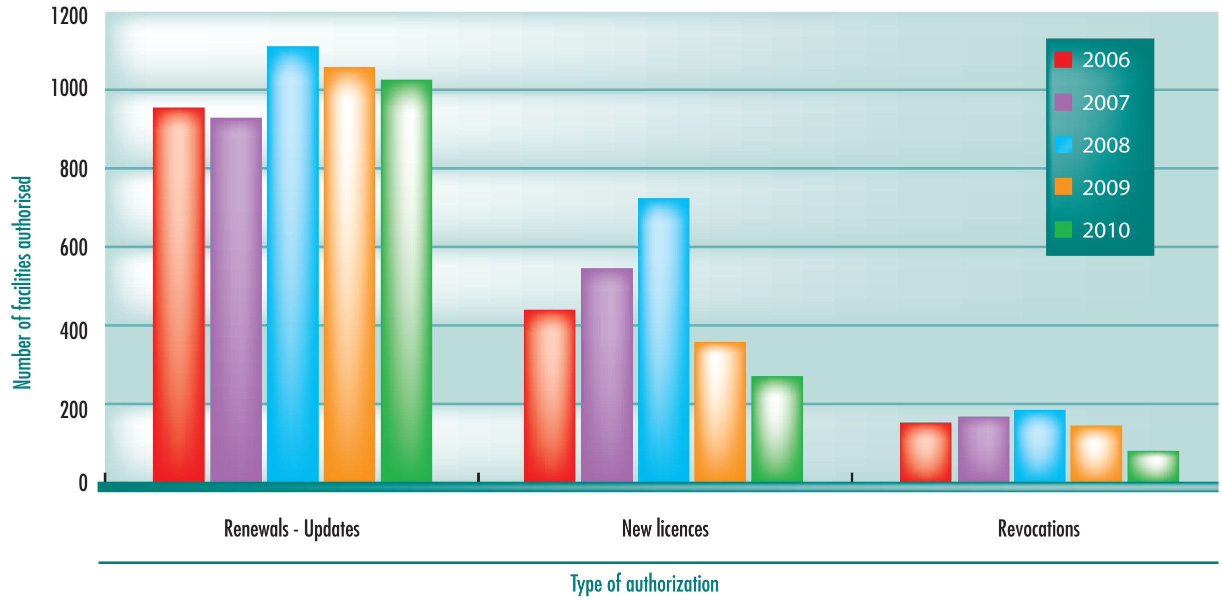
In 2010, 37 licenses were issued to suppliers.

Graph 5 presents the licenses issued or cancelled in 2010 and trends in this area between 2006 and 2010.

Graph 5: Radioactive source "supplier" licenses issued



Graph 6: Radioactive source "user" licenses issued



Users

In 2010, ASN reviewed and notified 279 new licenses, 1049 license renewals or updates and 88 license cancellations. Graph 6 presents the licenses issued or cancelled in 2010 and trends in this area between 2006 and 2010.

Once the license is obtained, the licensee may procure sources. To do this, it collects supply request forms from IRSN, enabling the institute to verify that the orders are in accordance with the licenses of both the user and the supplier, as it is 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 IRSN, which notifies the interested parties that delivery may take place. If any difficulty is encountered, IRSN informs ASN.

Electrical generators of ionising radiation

ASN has been responsible for regulating these devices since 2002, and is gradually building up its capacity in this area where numerous administrative situations need to be regularised. It granted 170 licenses and 98 license renewals for the use of electrical X-ray generators in 2010. Given the new regulatory provisions allowing the implementation of a notification system in place of the licensing system, ASN also delivered 759 notification receipts in 2010. A total of 1134 licenses and 759 notification receipts have been issued since decree no.2002-460 came into force.

2|2 Revocation of unjustified or prohibited activities

The Public Health Code imposes compliance with the principle of justification and specifies "the intentional addition of radionuclides in consumer goods and construction products is prohibited" (articles R. 1333-2 and 3 of the Public Health Code).

By virtue of the ban on the intentional addition of radionuclides in consumer goods and construction products (articles R. 1333-2 and 3 of the Public Health Code), the trade in irradiated gemstones, accessories containing tritium sources such as key-chains, hunting equipment (sighting systems) navigation equipment (compasses) or river fishing equipment (strike indicators) is prohibited.

Lightning arrester containing radium

For existing activities, justification will be reassessed if current know-how and technology so warrants. This is the case with smoke detection systems (see box) and various other activities that are disappearing, in particular owing to technological changes: dew point determination, level measurement and density measurement, for which X-ray or ultrasound techniques are tending to replace those using radionuclides, or snow height measurement and cable car gondola positioning systems using a radioactive source fixed in the support cable splices.

Box containing radioactive surge suppressors

Interior of box containing radioactive surge suppressors - radioactivity measurement in progress

Nevertheless, certain legacy objects containing radioactive sources are still present in France. Such is the case with lightning arrestors and surge suppressors installed on telephone lines.

The ban on the sale of radioactive lightning arresters was declared in 1987. At the present time, several thousand radioactive lightning arresters are allegedly still in service in France, and are sometime only discovered and removed during building maintenance or demolition operations. These objects contain sources with a significant level of activity that present exposure risks for people who come into contact with them, for example, when they are removed. The removal operations must therefore be carried out by specialised companies, and the objects must subsequently be directed to specialised disposal routes put in place by ANDRA, the French National Agency for Radioactive Waste Management.

Surge suppressors (sometimes called lightning arresters) are small objects with a very low level of radioactivity used to protect telephone lines against voltage surges in the event of lightning strike. The use of surge suppressors has been gradually abandoned since the end of the 1970s, but the number remaining to be removed, collected and disposed of is still very high (approximately 1 million units). Once installed, these devices do not present an exposure risk for people, but there can be a risk of contamination if they are handled without taking precautions. This risk must be taken into account in removal, interim storage and disposal operations in order to protect the public and workers, as required by the regulations.

ASN considers that even if these radioactive objects do not generally present a risk as long as they are not handled, they must be removed in a gradual and organised manner by specialised companies. For several years now, ASN has been informing the professionals to ensure that these radioactive objects are removed in a way that guarantees radiation protection of the workers and the public. ASN stepped up this action in 2009 and 2010 by sending reminders of the regulations to all the professionals concerned that it has identified, and by conducting on-site inspections of the companies involved in the recovery of these objects.

2|3 Determining the equipment inventory and ensuring compliance with the regulations

In 2010, in addition to drafting regulations, ASN continued with its more general work to improve familiarity with and understanding of the regulations and to promote compliance with them, both nationally and locally, through its regional divisions.

This enables ASN to reiterate the requirements of the regulations, to specify what it expects and to obtain direct feedback from the users concerning the constraints and problems they encounter.

ASN also pursued its action across the country to seek out any unlicensed suppliers distributing products in France. This action is aimed chiefly at the distributors of radioactive sources.

In this context, after having set up a licensing procedure for the use of electrical generators of ionising radiation in 2002, ASN wishes to supplement the provisions introduced into the Public Health Code in 2007, and thereby complete preparation of the regulatory framework enabling the distribution of these devices to be subject to licensing, as in the system applicable to radio-

Smoke detection

The aim is to signal an outbreak of fire as early as possible, by detecting the smoke produced. The devices used to date 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 exceeds a predetermined 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 radionuclides used to be utilised (americium 241, plutonium 238, nickel 63, krypton 85), at present only americium is marketed, with an activity level not in excess of 37 kBq for the most recent of them.

However, if just a few years ago this situation could be justified owing to the human safety advantages of this technique, this is no longer the case given that new detection techniques using alternative technologies have been developed and can comply with fire detection regulations and standards.

Radioactive smoke detector

Pursuant to article L.1333-1 of the Public Health Code, this change puts an end to the existing waiver arrangements allowing the addition of radionuclides to a construction product and requires that existing facilities be monitored with a view to replacing their ion detectors by an alternative technology. To implement this measure, ASN has submitted to the government a draft government order and two draft decisions proposing and regulating gradual replacement. These projects were submitted for consultation to various groups and entities representative of the stakeholders involved. They were also reviewed by the Advisory Committee for Radiation Protection.

It is estimated that 7 million ionic smoke detectors still exist, spread over 300,000 sites. In normal use, the structure of the device prevents any propagation of radioactive substances into the environment. ASN is preparing a process to inform the public on this subject.

active source suppliers. Experience shows that, in this respect, having the suppliers/manufacturers submit a technical file for review by ASN, brings substantial improvements in compliance with the optimisation principle.

However, for this equipment category, there are no technical references that can constitute a basis recognised by all stakeholders. ASN notes that for devices used for non-medical purposes, there is no counterpart to the medical CE marking confirming conformity with several European standards, covering a variety of fields, including radiation protection.

Operating experience feedback shows that a large number of devices carry no certificate of conformity with the standards applicable in France, even though this has been mandatory for many years, but which have become in part obsolete, owing to the absence of recent revisions.

Back in 2006, ASN contacted the Ministry of Work, the Central Laboratory of the Electrical Industries, the CEA and the IRSN, and urged the *Union Technique de l'Electricité* (UTE) to start updating these standards. The UTE initiated the revising of standards NF-C 15-160 and the associated specific standards (installation standards) that are currently being published.

With regard to equipment design, ASN has undertaken a reflection on the content of the radiation protection appraisals that have to accompany license applications. In 2010, it presented the state of progress of its work and the orientations envisaged for its Advisory Committee of Experts on radiation protection.

2|4 Monitoring of radioactive source protection against malicious acts

Even if the safety and radiation protection measures brought by the regulations do guarantee a certain level of protection against the risk of malicious acts, they cannot be considered sufficient. Tightening the monitoring of protection against malicious acts (a notion often summarized in the word “security”, as opposed to “safety”, which designates all the technical and organisational measures aiming to reduce the probability of accidents and, if an incident were to occur, to mitigate its consequences) targeting the most hazardous sealed radioactive sources was thus strongly encouraged by IAEA, which published a Code of Conduct on the Safety and Security of Radioactive Sources (approved by the Board of Governors on 8 September 2003) along with guidance on the import and export of radioactive sources (published in 2005). The G8 supported this approach, including at the Evian summit (June 2003) and France sent IAEA confirmation that it was working on implementation of the guidance stipulated in the Code of

Conduct (undertaken by the Governor for France on 7 January 2004). The general aim of the Code is to obtain a high level of safety and security for those radioactive sources which can constitute a significant risk for individuals, society and the environment.

Monitoring sources for radiation protection and safety purposes and monitoring them to combat malicious acts have many aspects in common and mutually consistent objectives. This is why ASN's counterparts abroad are usually responsible for monitoring both domains. ASN has the necessary hands-on knowledge of the sources concerned - which are regularly inspected by its regional divisions - to accomplish both missions.

The Government has therefore decided to task ASN with monitoring the security of radioactive sources, that is to say monitoring the prevention and the combating of terrorist acts targeting these sources. ASN has agreed to this mission on condition that it is given the necessary resources and can apply its rules of public information transparency. This mission will be accomplished in steps, according to the availability of the means, and if necessary ASN's monitoring action priorities will be reconsidered.

TO BE NOTED IN 2010

Reminder of the regulations following the incident on the DCNS site in Indret (Loire-Atlantique *département*[2])

Further to the incident of 5 January 2010 on the site of the DCNS group in Indret, ASN sent a letter stating the applicable regulations to gamma radiography companies which could use type TE 2000 electric remote controls.

The incident involved a company radiologist who entered the irradiation chamber before the radioactive source had fully retracted to its safe position. The radiologist was thus exposed for several seconds to a source of iridium 192 with an activity of about 1 TBq. The dose received by the radiologist in the incident was estimated at 0.3 mSv, which remains well below the annual regulatory dose limit of 20 mSv for persons who can be exposed to ionising radiation in the course of their professional activity.

ASN's investigations revealed numerous technical and organisational malfunctions behind this incident, including the use of a type TE 2000 remote control with a projector not equipped with a basic electric system. When a remote control of this type is used with an unequipped projector, the true positions of the source and of the radiation beam blocking device cannot be displayed on the remote control console. Yet it is vital to know these positions to ensure worker protection by avoiding involuntary exposure to doses that could be far higher than the dose estimated for the DCNS incident. Moreover, pursuant to article 9 of decree 85-968 of 27 August 1985 relative to gamma radiography devices, it is obligatory for electric remote controls to display the positions of the source.

ASN restated this regulatory requirement and the ban on the use of such remote controls with projectors not equipped with a basic electric device, and is continuing its investigations into the other electric remote controls used in gamma radiography.

Feursmetal incident in Feurs (Loire *département*)

On 26 May 2010, six people, premises and items of tooling were contaminated in the Feursmetal foundry during an attempt to retrieve a high-activity (1.25 TBq) cobalt 60 radioactive source that was jammed in the ejector tube of a gamma ray projector.

The gamma ray projector and the jammed source had been situated since 7 May in a bunker on the Feursmetal site where the projector is regularly used to inspect castings. After failure of the first attempt to release the source on 10 May assisted by the technical teams of Cegelec, the manufacturer, a second operation was scheduled for 26 May with the assistance of IRSN. It was during this second operation, carried out using robots that the source was accidentally sheared, resulting in the dispersal of radioactive contamination within the bunker and the adjacent premises, where the six workers were present.

The six people were placed in the care of specialist teams and transferred to the specialised medical unit of EDF's Saint-Alban nuclear power plant. The dosimetric impact on the workers was evaluated at between 0.2 mSv and 0.6 mSv depending on the individual. Although the human consequences were limited, the material consequences were quite considerable, as significant contamination was detected in the bunker, in the adjacent premises and in certain peripheral areas within the company. Furthermore, foundry moulds stored in the premises adjoining the bunker were also contaminated, and these items are necessary for the fabrication of the steel castings that Feurmetal produces.

ASN classified this event at level 2 on the INES radiological events scale (which goes from 0 to 7).

The first phase of the decontamination work, regulated by a prefectoral order, began in June with the moulds and the peripheral areas. Decontamination of the foundry moulds is progressing and clean-out of the peripheral areas is completed. Bunker decontamination operations will be carried out in a second phase to allow clean-out of the bunker and adjacent premises.

2. Administrative region headed by a *préfet*

3 MONITORING NON-MEDICAL ACTIVITIES

3|1 Checks conducted by ASN

The checks applied to radiation sources are adapted to the nature and use of the sources. They are presented in chapter 4.

In the industrial sector, ASN is particularly attentive to facilities using gamma radiography devices, accelerators and high-activity sources. ASN has placed the inspection of these facilities among its priority inspection themes.

For the implementation of its industrial inspection programme, ASN has identified other high implication areas, notably suppliers of sources and electrical devices emitting ionising radiation, their utilisation on work sites, and the inspection of facilities that fail to comply with the regulations.

3|2 Main incidents in 2010

ASN also controls the handling of the incidents notified to it. These 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, in addition to accidental irradiation of individuals.

ASN was notified of 75 radiation protection events in the non-medical and non-BNI area in 2010. Some of these events are recurrent.

One incident was classified level 2 on the INES scale (see box on the Feursmetal incident). Of the others, 23 were classified level 1 (anomaly) and 51 were classified level 0 (deviation).

The main event categories are exposure of individuals and the discovery, loss or theft of sources.

Losses usually concern calibration sources, especially those used to calibrate or verify measuring instruments.

Thefts mainly concern devices for detecting lead in paint which are kept in attache-cases or in strongboxes. They are sometimes found a short time after the theft.

Discoveries concern a wide variety of objects, mainly detected by the gates at BNI exits or at the entrances to landfills and scrap yards. These sources can come from private individuals, they can be found in establishments which had forgotten they had them, or can be left on the street, for example in front of a police station. Events concerning contaminated metals are also considered to be source discoveries (see box).

Human exposures are chiefly due to irradiation. Industrial gamma radiography practices were again incriminated in the majority of cases this year. A new type of generic event is the involuntary irradiation of individuals by tomography devices during verifications by the authorities to detect illegal items in containers or lorries.

3|3 Dosimetry in the non-medical sector

According to the most recent data collected by IRSN concerning external occupational exposure in 2009, more than 83,000 people working outside BNIs and the medical sector are subject to exposure monitoring.

Of these workers, in the year, 92% received an effective dose below 1 mSv, 6.4% an effective dose between 1 and 6 mSv, 1.5% received between 6 and 20 mS, and 0.01% exceeded 20 mSv. This distribution results from the new activity sectors nomenclature established by IRSN this year. The average dose received by these workers is 360 µSv.

TO BE NOTED IN 2010

Imports of items contaminated by Cobalt 60 – Radioactivity detection

As in previous years, cases of contamination by radioactive cobalt 60 were detected in imported industrial parts. Several events of this type have continued to be reported across the world. More particularly:

- *an accident occurred in April 2010 on a metal recycling site in India, and was classified level 4 on the INES international radiological events scale;*
- *more recently, in July 2010 in the Italian port of Gênes Voltri, a container shipped from Saudi Arabia was found to have a contact dose rate of more than 600 mSv/h.*

Although ASN has observed an improvement in the management of this type of incident by companies, it also notes their increasing numbers. These recent events show that when radioactive materials are not specifically labelled as such, they can be sent to France or other countries with no specific and systematic checks at the borders. At present, the French regulations concerning the transport of goods at the French borders do not provide for specific checks to search for radioactive materials.

In this context, ASN has several times alerted the ministries concerned of the worrying increase in events of this type, the health and economic consequences of which can be considerable, and has proposed a national reflection on the deployment of radioactivity detection systems at strategic points around the country (ports, road hubs, airports).

4 ASSESSMENT OF RADIATION PROTECTION IN THE NON-MEDICAL SECTOR

Industrial radiography

In this sector, where the radiation protection stakes are high and incorrect use of devices can rapidly have serious health and financial impacts, especially in the case of gamma radiography, ASN places high priority on inspection actions.

ASN finds contrasting situations in the way companies take into account the risk of worker exposure to ionising radiation, and considers that further improvements can be made. Although on the whole the regulations relating to worker training and the periodic external inspection of sources and devices are satisfied, further progress must be made in work preparation, particularly for on-site operations (predicted dose evaluations, marking out of zones, etc.) and in the coordination between the ordering companies and the contractors, to enhance work preparation and allow the application of effective preventive measures. Regional programmes to draw up good practice charters have been initiated in the Provence-Alpes-Côte d'Azur, Haute-Normandie and Rhône-Alpes regions and more recently in Nord-Pas de Calais and Bretagne/Pays de Loire. These initiatives, some of which are more recent than others, must be continued in order to allow regular exchange between the stakeholders.

Foodstuff X-ray scanner

More broadly, as regards justification and optimisation, continuation of the reflections initiated by the non-destructive testing professionals and application of the available guides will be impossible without the active involvement of the ordering companies. This includes the Alter'x association project, which started in 2006 and was coordinated by the Institut de Soudure and comprised EDF, GRTgaz, Technip and Total. At the end of 2009, it published a guide offering solutions to industrial firms looking for an alternative to gamma radiography of piping welds using Iridium 192. This guide was drafted with a view to reducing operator dosimetry and public exposure and contains aspects regarding both optimisation (selenium 75, X-rays) and justification (alternative techniques not involving ionising radiation). More recently, Cofrend and various stakeholders undertook work on the justification of gamma radiography, and finalised a study that aims at explaining the principle of gamma radiography justification in the field of non-destructive testing. The purpose of this document, which will contain functional tools such as a flowchart identifying the conditions in which gamma radiography can be replaced, and tables describing the tests and their purpose, is to promote the use of alternative methods.

Research

ASN's monitoring of establishments and laboratories using radioactive sources for research purposes, which began in 2002, shows a distinct improvement in radiation protection in this sector. The actions taken over the last few years have produced appreciable results, particularly in the involvement of Persons Competent in Radiation protection (PCRs), the training of exposed workers and radiation protection technical inspections.

ASN notes a gain in overall awareness of the importance of radiation protection issues. This being said, the lack of involvement of certain stakeholders and the considerable legacy of installations to be brought into conformity with radiation protection requirements, combined with removal of very old and "forgotten" radioactive sources, can represent serious obstacles.

Veterinary

The veterinary profession uses X-ray generators for radiodiagnostic purposes in the standard radiography context. eighty-five percent of the 6,500 veterinary clinics have at least one radiography installation. These installations also include some fifteen computer tomography scanners, three scintigraphy centres and one brachytherapy centre.

The profession counts approximately 15,500 veterinary surgeons and 14,000 non-veterinary employees. Veterinary radiodiagnostic activities essentially concern pets.

The inspections carried out in 2010 showed that the administrative situation of veterinary installations was still not satisfactory (lack of license or notification). The radiation protection technical inspections, the workstation studies and risk analyses must be improved. ASN has nevertheless observed major progress over the last years. At present, the large majority of structures have a PCR and the workers are subject to exposure monitoring.

Nearly 850 veterinary offices have put their administrative situation into order (notification or license). Implementation of the notification system for certain veterinary activities led to a large increase in the number of files submitted to ASN in 2010.

ASN maintains regular contact with the professional veterinary organisations. This has resulted in significant improvements in radiation protection in this sector, which is gearing itself to improve the integration of radiation protection aspects and to disseminate good practices. A website dedicated to radiation protection has been set up, along with a network of national and regional referral agents, to support the profession's 3,500 PCRs. Their actions are also materialised by the drafting of typical documents and guides for veterinarians, and the publication of radiation protection articles in the professional press. A first guide for the canine sector has already been finalised, along with good radiodiagnostic practices sheets for the equine sector, where the radiation protection implications are highest.

5 OUTLOOK

In the field of regulating applications of ionising radiation in the non-medical sector, ASN works to ensure that the operators take full account of the risks involved in the use of ionising radiation. This problem is accentuated by the diversity and the number of the parties involved. Recent incidents in France and serious accidents abroad, for example in the field of gamma radiography, demonstrate once again the need for scrupulous implementation of the regulations and stringent operations. With this aim in view, as in 2010, ASN will continue the monitoring of radioactive source suppliers in 2011, for both the reviewing of license application files and the inspections performed in these entities. With regard to users, it will pay particular attention to on-site utilisation of ionising radiation sources and to seeking out entities that are not in conformity with the regulations.

ASN will also continue its work to implement equivalent regulations for the suppliers of electrical devices emitting ionising radiation.

Following the incidents related to gamma radiography sources, ASN initiated specific, targeted monitoring actions on high-level sources. It will continue these actions, placing emphasis on the security-related aspects, in anticipation of its new duties.

The 2010 initiative to publish the follow-up letters to the inspections ASN conducted in the non-medical sector will be continued in 2011.

ASN endeavours to constantly improve its knowledge of the players and organisations in the industry and in research, with the aim - among other things - of stepping up the verification of the justification for using radioactivity when reviewing license applications, and to encourage integration of the principle of optimisation from the equipment design stage. In the specific domain of gamma radiography, these objectives concern as much the gamma radiography contractors as the ordering companies, which are often directly involved in the choice of non-destructive testing techniques used on their site.