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 currently in force is to check that the safety of workers, the public and the environment is ensured. This protection includes source management, monitoring of the conditions in which sources are held, used and disposed of, from fabrication through 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 the regulation activities for which ASN is responsible.

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 that do not fall under the framework of the basic nuclear installations (presented in chapters 12, 13 and 14). All other applications however, including those carried out within installations classified on environmental protection grounds (ICPEs), are concerned. The main activity sectors are presented below.

1 PRESENTATION OF 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 described below.

1|1|1 Industrial irradiation

Industrial irradiation is used for sterilising medical equipment, pharmaceutical or cosmetic products and for the conservation of foodstuffs. It is also a means of voluntarily modifying the properties of materials, for example, to harden polymers.

These consumer product irradiation techniques can be authorised because, after being treated, these products display no residual artificial radioactivity (the products are sterilised by passing through radiation without themselves being “activated” by the treatment). 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

Gamma radiography device on work site

sources of iridium 192, cobalt 60 and, more recently, selenium 75, whose activity can reach about twenty terabecquerels at the most. 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;
– a guide 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;
– 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 physical parameter verification 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 kilo becquerels (kBq) and a few giga becquerels (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 the filter, which enables this amount to be determined. The most commonly used sources are carbon 14 (activity level: 3.5MBq) or prometheum 147 (activity level: 9MBq). 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 not exceeding 3GBq;
– 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: 1.7GBq), caesium 137 - barium 137m (activity level: 37MBq) 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: 2GBq), caesium 137 - barium 137m (activity level: 100 MBq) or cobalt 60 (30GBq);
– 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 sub-soil to be examined by inserting a measurement probe comprising a source of cobalt 60, caesium 137, americium 241 or californium 252.

1|1|4 Neutron activation

Neutron activation consists in irradiating a sample with a flux of neutrons to activate the atoms in the sample. The number and the energy of the gamma photons emitted by the sample in response to the neutrons received 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 analysis of the chemical characteristics of the cement constituent materials. There are some thirty cement works in France, and three of them use this technology. To use of this technology, which activates the analysed material, it is necessary to obtain a waiver as provided for by Article R.1333-4 of the public health code. ASN was referred to by the Government, firstly to examine a waiver application for the use of a neutron analysis device in a cement works (ASN opinion 2011-AV-0105 of 11/01/2011), and secondly to give an opinion on a draft order granting that waiver (ASN opinion 2011-AV0124 of 07/07/2011).

The waiver to the ban on adding radionuclides for the purpose of neutron analysis in the manufacture of cement was granted by an order of 18 November 2011 from the ministers in charge of health and construction (*Official Journal* of 3 December 2011).

Reminder: *Article R.1333-3 of the Public Health Code [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 this same code provides that ***"waivers (to these prohibitions] can, if they are justified by the advantages they bring in relation to the health risks they can represent,*** *be granted by order of the minister in charge of health and, depending on the case, by the minister in charge of consumption or the minister in charge of construction, after consulting 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. This technique is particularly useful in detecting lead in paint. The portable devices used today contain sources of cadmium 109 (half-life 464 days)

Device for detecting lead in paint

or cobalt 57 (half-life of 270 days). The activity of these sources can range from 400 MBq to 1500 MBq. This technique, which uses 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 1st January 1949, if it is to be sold or to undergo works significantly affecting the surface coatings in the common parts of the building.

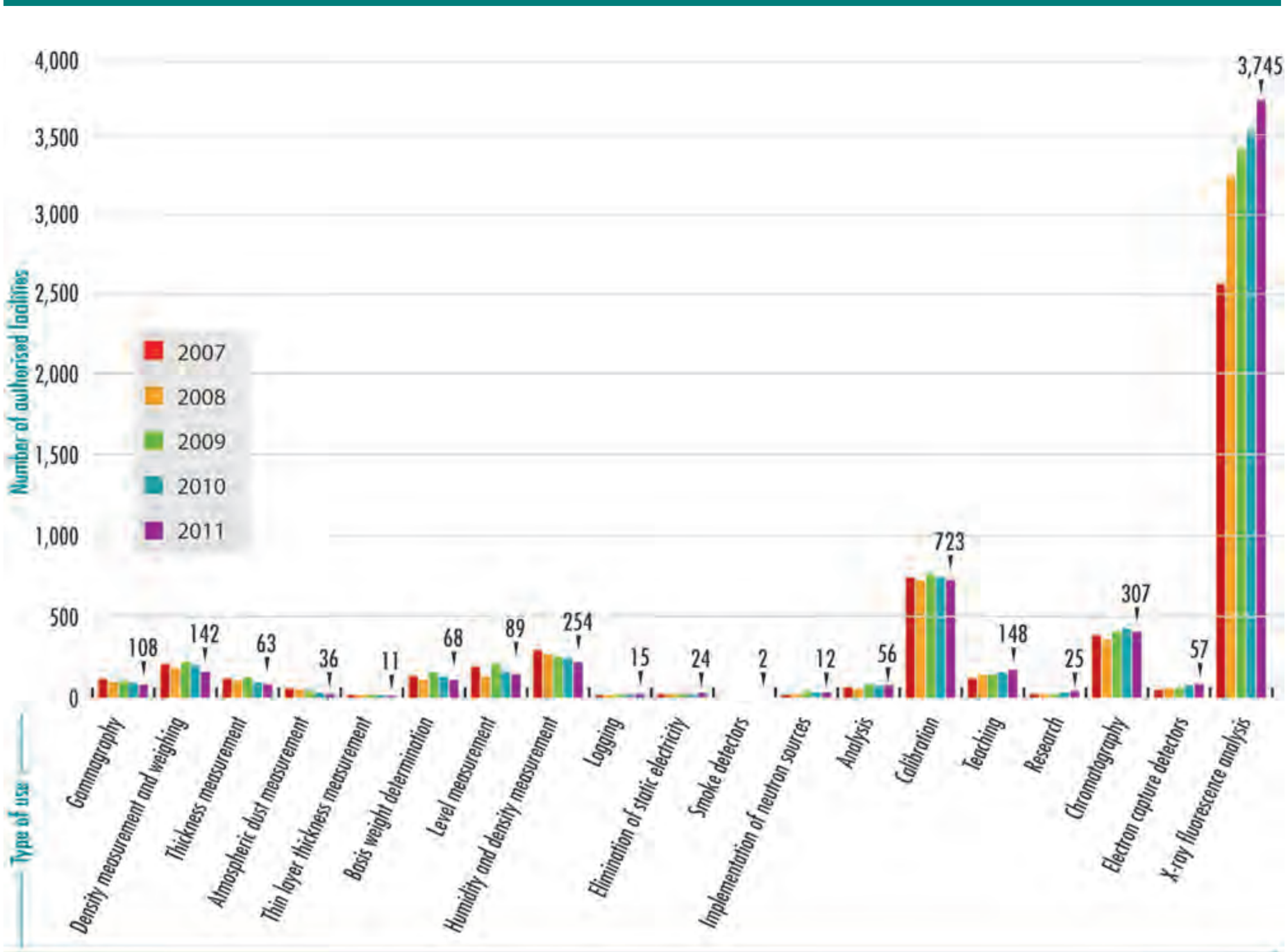
Graph 1 specifies the number of facilities authorised to use sealed radioactive sources for the applications identified. It illustrates the diversity of these applications and their development over the last five years (from 2007 to 2011).

It should be noted that a given facility may carry out several activities, and if it does, it appears in graph 1 and the following diagrams for each activity.

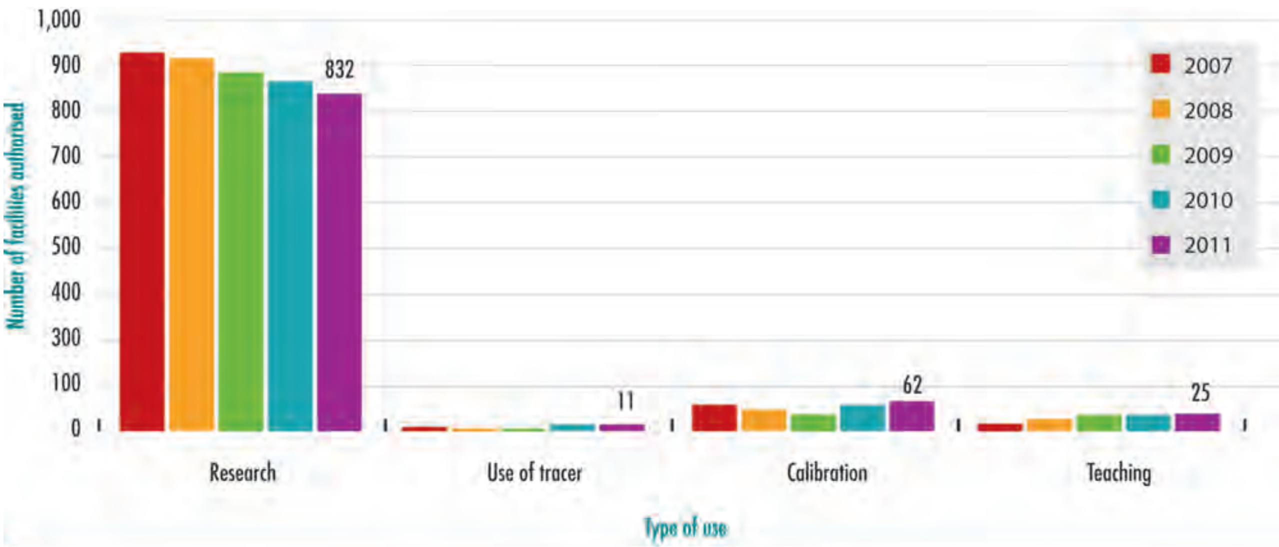
1|2 Unsealed radioactive sources

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

Graph 1 : use of sealed radioactive sources



Graph 2: use of unsealed radioactive sources



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 or friction spots, for building hydrodynamic models and in hydrology.

The number of facilities authorised to use unsealed sources stands at 930.

Graph 2 specifies the number of facilities authorised to use unsealed radioactive sources in the applications identified in the last five years (from 2007 to 2011).

1|3 Electrical devices emitting ionising radiation

Graphs 3 and 4 specify the number of facilities authorised to use electrical devices generating ionising radiation in the listed applications. It illustrates the diversity of these applications and they have evolved over the last five years (from 2007 to 2011). 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. At present, the situation of the professionals concerned is being brought into compliance in many activity sectors, but a large number of users have not yet taken any action.

1|3|1 Industrial applications

The electrical devices emitting ionising radiation are chiefly X-ray generators. Like the devices containing radioactive sources, they are used in industry, non-destructive structural analyses (analysis techniques such as tomography, diffractometry, also called X-ray crystallography, etc.), checking the quality of weld beads or inspecting materials for fatigue (in aeronautics in particular).

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.

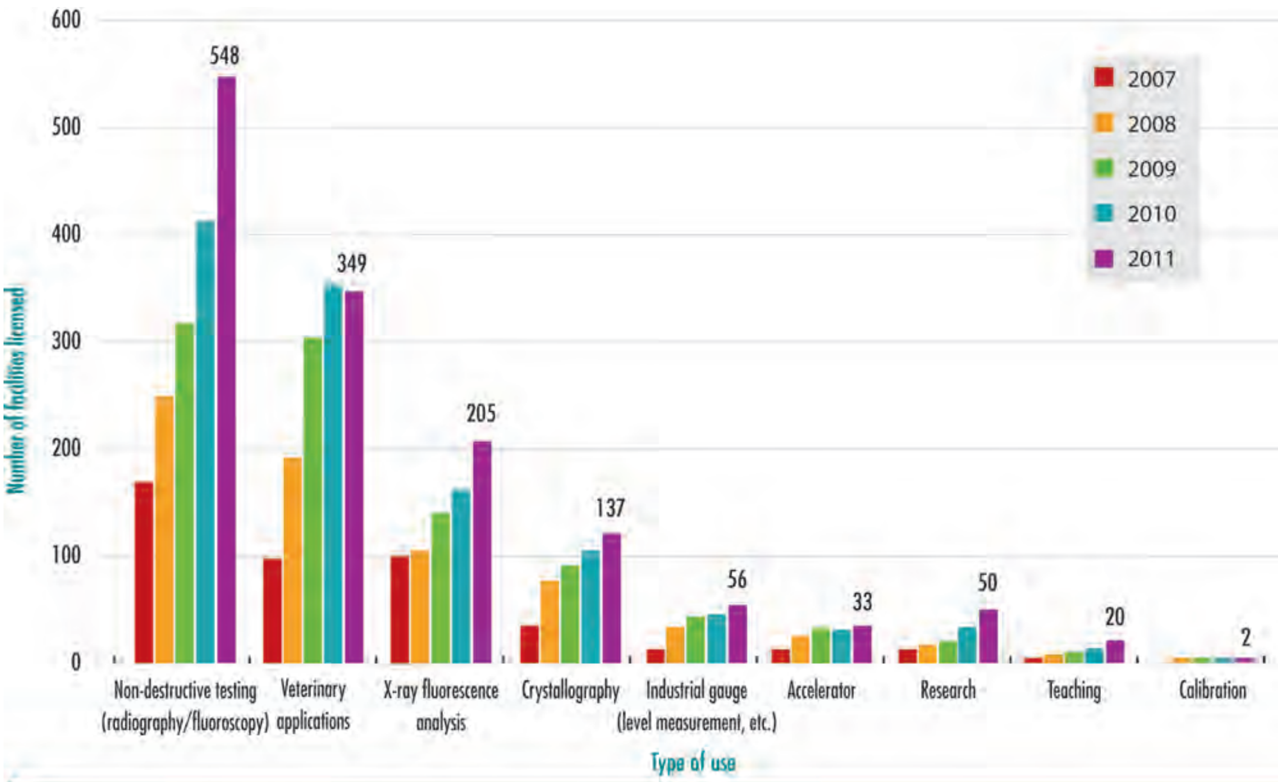
The increasing number of types of device available on the market can be explained more particularly by the fact that when possible, they replace devices containing radioactive sources. The advantages of this technology are significant with regard to radiation protection, given the total absence of ionising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

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

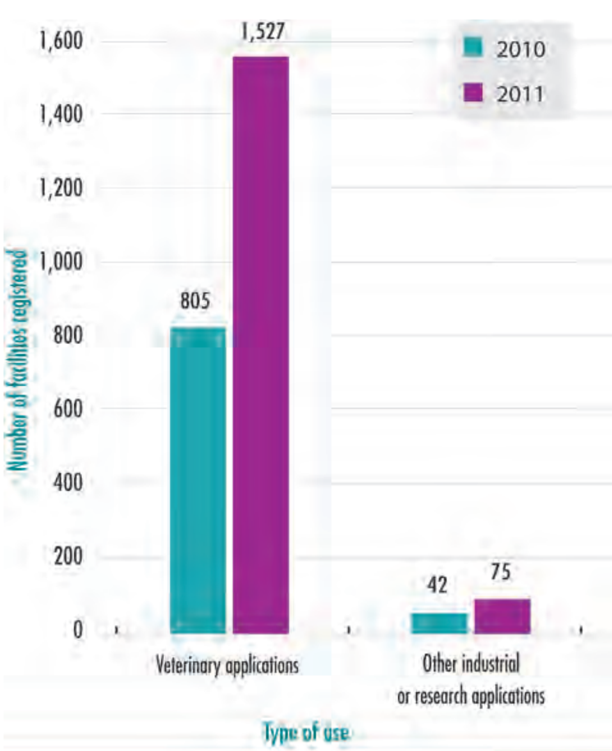
These are fixed or worksite devices that use directional or panoramic beams. These devices can also be put to more specific

Baggage screening system from the Hi-Scan product range

Graph 3: use of electrical devices generating ionising radiation (activities subject to licensing)



Graph 4: use of electrical devices generating ionising radiation (activities subject to notification)



uses, such as radiography for restoration of musical instruments or paintings, archaeological study of mummies or analysis of fossils.

Baggage inspection

Ionising radiation is 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 screening checkpoints in airports, in museums, at the entrance to certain buildings, etc.

The devices with the largest inspection tunnel areas are used for screening large baggage items and hold baggage in airports, as well as for air freight inspections. This range of devices is supplemented by tomographs, which reconstruct the volume of an object from a series of cross-sectional image slices.

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

X-ray body scanners

After the failure of several attempted terrorist acts in recent months, X-ray body scanner technologies are the subject of growing interest, particularly in airports where there use is envisaged to reinforce security checks.

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.

X-ray device for screening foodstuffs

The experiments currently under way in France use image-generating technologies based on non-ionising millimetre waves.

Various technologies using X-rays have been developed and are already used in other countries:
– 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 about 0.1 microsievert (µSv) per scan). This technology is used in the United Kingdom and the USA, for example;
– 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 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).

The members of the association HERCA (Heads of European Radiological Protection Competent Authorities) have recognised the need to define a common European approach on the justification of the use of X-ray body scanners. They adopted a joint position on the subject on 1st December 2010. The declaration, which can be consulted on the HERCA web site *(www.herca.org)*, reaffirms the importance of applying the three principles of dose justification, optimisation and limitation in full, whatever the dose received by the persons concerned at each screening by an X-ray scanner.

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

The profession counts approximately 16,000 veterinary surgeons and 14,000 non-veterinary employees. Veterinary surgeons use radiodiagnostic devices in a similar context to that of the devices used in human medicine. Veterinary radiodiagnostic activities essentially concern pets.
– 90% of the 5,793 veterinary clinics have at least one radiodiagnostic device;
– ASN moreover notes an increase in the number of computed tomography scanners used in veterinary applications, with about fifteen in France at present;
– projects for implementing other practices drawnfrom the medical sector have materialised more recently. Three scintigraphy centres and one brachytherapy centre are identified on the national scale.

The treatment of horses requires powerful devices installed in specially equipped premises (radiography of the pelvis, for example) and portable X-ray generators, used either inside premises - dedicated or not - or outside in the open air. This activity, which has strong radiation protection implications for the veterinary surgeons, will be one of ASN's inspection priorities in 2012.

Veterinary equine X-ray examination

Relocatable linear accelerator used for inspecting loads

Mobile linear accelerator used for inspecting loads

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.

1|4 Particle accelerators

The Public Health Code defines an accelerator as a device or installation in which electrically charged 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.

In the field of research, a number of synchrotron radiation production installations can be mentioned: the ESRF (European synchrotron radiation facility) in Grenoble, and the SOLEIL synchrotron at Gif-sur-Yvette.

1|5 Other 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 BNI regulations), ion implanters, electron-beam welding equipment, klystrons, certain lasers, certain electrical devices such as the 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:

6 MeV Varian linear accelerator and its collimator

– a ban on activation of construction products, consumer goods and foodstuffs as specified by Article R.1333-4 of the Public Health Code, by ensuring that the maximum energy of the particles emitted by the accelerators used rules out any 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. Thus, the use of ionising technologies to seek out illegal immigrants in transport vehicles is prohibited in France;
– the setting up of procedures to check that the verifications conducted on the goods or transport vehicles do not lead to accidental exposure of workers or the public. During customs inspections of trucks using tomographic techniques, for example, the drivers must be kept away from the vehicle and other checks must be performed prior to irradiation to detect the presence of any illegal immigrants, in order to avoid unjustified exposure of persons during the inspection.

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 Integration of the fundamental principles of radiation protection in the regulation of non-medical activities

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.

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 does not seem to outweigh the risk. In this case, either prohibition is declared generically, or the license required on account of radiation protection is not extended. The uses of radium for which the detriment to health was considered too high were banned several decades ago in application of this principle. For existing activities, justification is reassessed when license renewal applications are made if current know-how and technology so warrants.

Optimisation is a notion that must be considered in the technical and economic context, and it requires a high level of involvement of the professionals. ASN considers in particular that the suppliers of non-medical devices must be at the core of the optimisation approach (see 2|3). They are responsible for putting the devices on the market and must therefore design them such that the exposure of the future users is minimised. ASN also checks application of the principle of optimisation when examining the license application files, when conducting its inspections, and when analysing the various significant events notified to it.

2|2 The Authorities regulating the sources of ionising radiation

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 public health code does nevertheless provide for a series of waivers to alleviate the licensees' administrated constraints. 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 same 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 the installations licensed under the BNI regime pursuant to Act 2006-686 of 13 June 2006 relative to transparency and security in the nuclear field (now codified in books I to V of the environmental code by Order 2012-6 of 5 January 2012), ASN regulates, under this regime, the sources necessary for the functioning of these same 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, however, are not concerned by these waivers, and are subject to ASN authorisation.

Nuclear materials, for their part, are subject to specific regulations provided for in Article L. 1333-2 of the defence code. Application of these regulations is overseen by the Minister of Defence for nuclear materials intended for defence needs, and by the minister in charge of energy for nuclear materials intended for any other use.

2|3 Licensing and notification of ionising radiation sources used for non-medical purposes

2|3|1 Applicable licensing and notification legal system

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 licensing regime

The initiative implemented by ASN to have a simplified and graduated approach according to the radiological risks and implications was continued in 2011 with the revising of the license application forms. Following on from the issue of the ASN decision specifying the content of the files to include with the license applications (decision 2010-DC-0192), new forms setting out the provisions of this decision were drawn up and issued in 2011:

– the application form for a license to hold / use devices containing radioactive sources for the purpose of detecting lead in paint (AUTO/IND/PLOMB);
– the application form for a license to exercise an activity in industrial radiography / fluoroscopy (AUTO/ IND/RADIO).

Other forms will be forthcoming, including :
– the application form for a license to hold, use or manufacture sealed radioactive sources (AUTO/IND/SS);
– the application form for a license to hold, use or manufacture non-sealed radioactive sources (AUTO/IND/SNS).

These forms list the documents that must be enclosed with the application. This list is established applying a graduated approach to the risks according to the envisaged nuclear activity.

All the documents listed in the appendix to ASN decision 2010-DC-0192 of 22 July 2010 must of course be held by the applicant and kept available for the inspectors in the event of verification. It is moreover possible that ASN will request further information during its examination of the license application.

To better integrate the true situation of responsibilities in the non-medical sectors, where the radioactive sources and devices are more often managed by an entity than by an individual, these new forms provide the possibility of making license applications as a representative of an artificial person, in application of Article R. 1333-24 of the public health code.

All the forms relative to non-medical small-scale nuclear activities will be reviewed, applying the formality and principles of the above-mentioned forms.

The notification system

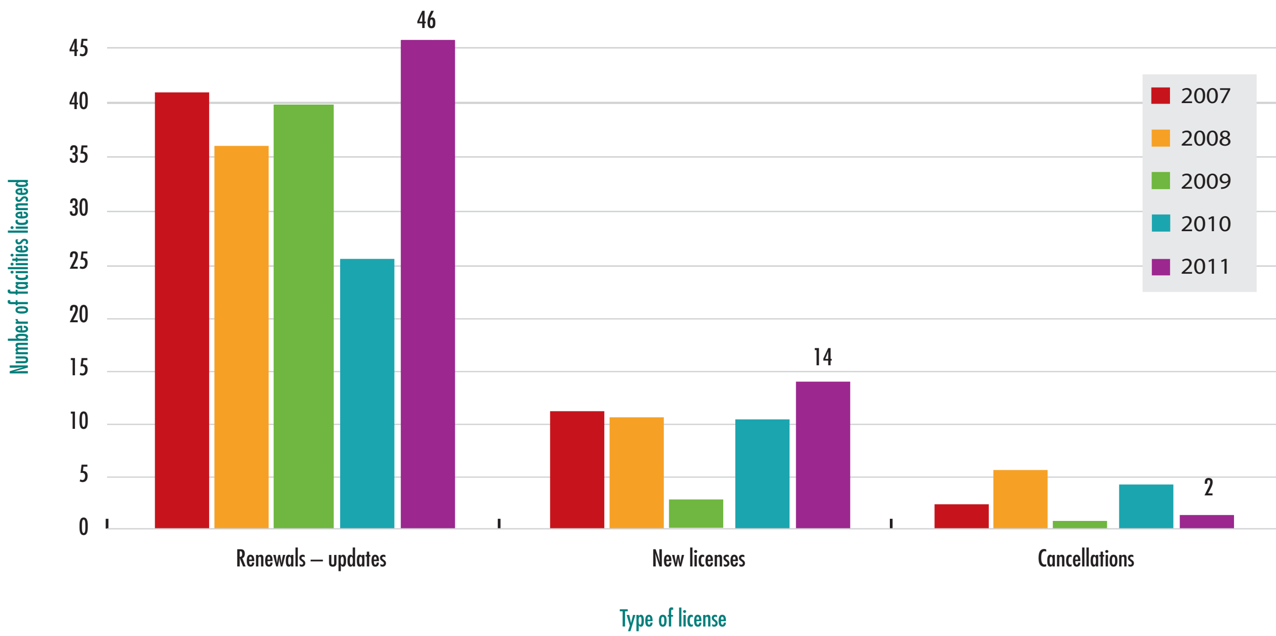
To achieve a balance in the sectors of activity subject to notification or licensing, and therefore better adapt the regulatory requirements to the radiation protection implications, ASN introduced a notification system in the non-medical sector in 2009. This led to the publication of several approved 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, *Official Journal* of 26 February 2010);
– electrical devices emitting ionising radiation, for which the equivalent dose rate at 10cm from all accessible surfaces in normal conditions of use and as a result of their design, is less than 10 µSv.h-1.

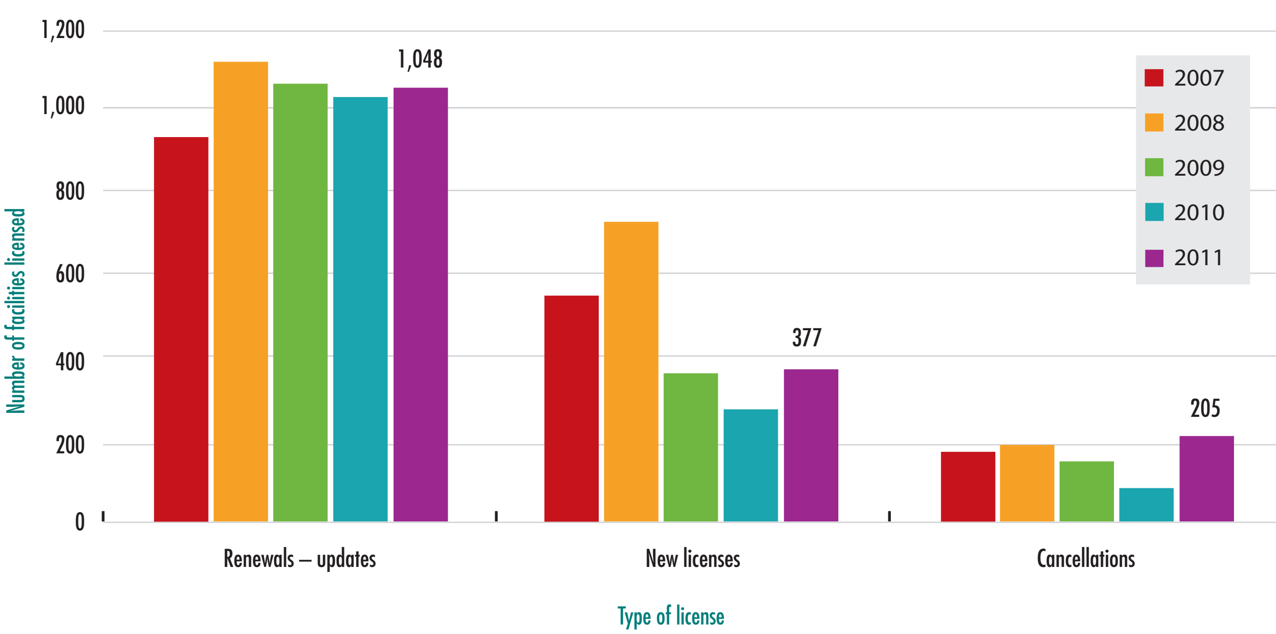
The notification form drawn up by ASN to facilitate application of decision 2009-DC-0148 defining the detailed content of the information to be appended to the notifications has been designed so as to simplify its utilisation and processing. No document has to be added to the notification form if the devices declared meet the requirements specified in ASN's decisions and are eligible for this system.

1. In a *département*, representative of the State appointed by the President. The Ministry of Defence substitutes for the *Préfet* for the ICPEs situated on military sites. In other respects, ASN exercises the functions of the *Préfet* for the ICPEs located within the bounds of a BNI.

Graph 5: radioactive source "supplier" licenses delivered



Graph 6: radioactive source "user" licenses delivered



2|3|2 Statistics for 2011

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 2011, 60 licenses or license renewals were issued to suppliers.

Graph 5 shows the licenses delivered in 2011 and the trends for license deliveries over the last five years (from 2007 to 2011).

Users

Case of radioactive sources
In 2011, ASN reviewed and notified 377 new licenses, 1,048 license renewals or updates and 205 license cancellations. Graph 6 presents the licenses issued or cancelled in 2011 and trends in this area for the last five years.

Once the license is obtained, the licensee can procure sources. To do this, it collects supply request forms from the Institute of Radiation Protection and Nuclear Safety (IRSN), enabling the institute to verify - as part of its duty to keep the inventory of ionising radiation sources up to date - that the orders are in conformity with the licenses of both the user and the supplier. If the order is correct, the movement is then recorded by IRSN, which notifies the interested parties that delivery can 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 198 licenses and 126 license renewals for the use of electrical X-ray generators in 2011. Given the new regulatory provisions allowing the implementation of a notification system in place of the licensing system since 2010, ASN also delivered 755 notification receipts in 2011. A total of 1,314 licenses and 1,602 notification receipts have been delivered for electrical devices emitting ionising radiation since decree 2002-460 was issued.

2|4 Revocation of unjustified or prohibited activities

2|4|1 Application of the ban on the intentional addition of radionuclides in consumer goods and construction products

The public health code indicates "*that the intentional addition of radionuclides in consumer goods and construction products is prohibited*" (Articles R. 1333-2 and 3 of the public health code, see 2|1|3 of this chapter).

The trading of radioactive stones or decorative objects, accessories containing sources of tritium such as watches, key-rings, hunting equipment (sighting devices), navigation equipment (bearing compasses) or equipment for river fishing (strike detectors) is specifically prohibited.

Several findings of radioactive substances in consumer goods were reported to ASN in 2011. A number concerned the presence of small quantities of radionuclides of natural origin in technical ceramics imported from Asia and used in consumer goods (textiles and certain laundry balls, for example). ASN was thus induced in 2011 to remind companies importing components or products based on technical ceramics, particularly from Asia, that any use of radioactivity must be justified by the benefits it brings, and that any advertising relative to the use of radionuclides or products containing radionuclides is prohibited by the public health code. With regard to consumer goods, the intentional addition of radionuclides - including those of natural origin - for their radioactive properties, is strictly prohibited.

2|4|2 Application of the principle of justification for existing activities

In application of the principle described in point 2|1, the justification of existing activities must be re-assessed periodically in the light of current knowledge and the way techniques evolve. If the activities are no longer justified by the benefits they bring, or with respect to other non-ionising technologies that bring comparable benefits, they must be withdrawn from the market. A transient period for definitive withdrawal from the market may be necessary, depending on the technical and economic context, particularly when a technological substitution is necessary.

Smoke detectors containing radioactive sources

Devices containing radioactive sources have been used for several decades to detect smoke in buildings, as part of the fire-fighting policy. These devices comprise two ionisation chambers, of which only one allows the combustion gases to enter. By comparing the strength of the current crossing the two chambers, a change in the atmosphere can be detected when the smoke enters the unsealed chamber. This triggers the fire alarm. Several type of radioisotopes were initially used to ionise the content of the two chambers (americium 241, plutonium 238, nickel 63, krypton 85), but only americium is currently used in the smoke detectors available on the market. The activity of the most recent sources used does not exceed 37 kBq, and the structure of the detector, in normal use, prevents any propagation of radioactive substances into the environment.

New non-ionising technologies have gradually come to compete with these devices. Optical devices now provide comparable detection quality, and can therefore satisfy the regulatory and normative fire detection requirements. ASN therefore considers that smoke detection devices using radioactive sources are no longer justified and that the seven million ionic smoke detectors installed on 300,000 sites must be progressively replaced.

Regulatory changes were developed on the basis of the ASN proposal. They were submitted for consultation to various groups and entities representative of the stakeholders involved. They were also examined by the Advisory committee of experts in radiation protection (GPRAD), the HCSP (French High Public Health Council), the Simplification Commissioner, and the CCEN (Consultative Committee for the Evaluation of Standards). A presentation note was posted on the web site of the HCTISN (French High Committee for Transparency and Information on Nuclear Security).

The order introducing the waiver to Article R.1333-2 of the public health code for ionisation chamber smoke detectors was signed on 18 November 2011, further to ASN opinion 2011-AV-0134, and published in the *Official Journal* on 3 December 2011. The regulatory provision is supplemented by two ASN decisions:
1. Decision 2011-DC-0252 of 21 December 2011 subjecting certain nuclear activities to notification in application of 2° of Article R. 1333-19 of the public health code;
2. Decision 2011-DC-0253 of 21 December 2011 defining the particular conditions of use and the procedures for the registration, monitoring, recovery and disposal of ionisation chamber smoke detectors.

Reconditioning of smoke detectors

Surge suppressors

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. These risks must be taken into account in the removal, storage and disposal operations in order to protect the public and the workers. ASN issued a reminder of this to France Télécom, which is currently drawing up a plan of action to organise the removal and disposal of surge suppressors in compliance with the regulations.

Lightning arresters

In 1914, Léo Szilard, a Hungarian scientist, developed the first lightning arrester with a radioactive head. In 1932 the French company Hélita put the first radioactive lightning arrester onto the market. Companies subsequently developed other products, including the brands Duval Messien, Franklin France and Indelec. Having radioactive sources on the head of the lightning arrester was supposed to increase the protection radius compared with a "conventional" lightning arrester, by rendering conductive the air around the sealed sources. The arresters were equipped, according to their type, with sealed sources of radium 226, and subsequently americium 241.

Radioactive lightning arresters were manufactured and installed in France between 1932 and 1986. The ban on the sale of radioactive lightning arresters was declared in 1987. This order did not make the removal of installed radioactive lightning arresters compulsory. Consequently, there is no obligation to remove the radioactive lightning arresters installed in France at present, apart from in certain ICPEs (order of 15 January 2008 setting the removal deadline at 1 January 2012) and certain installations under Ministry of Defence responsibility (order of 1 October 2007 setting the removal deadline at 1 January 2014).

ANDRA, the national agency for radioactive waste management, estimates that there are still 40,000 radioactive lightning arresters installed in France. ASN considers that these radioactive objects - even if they generally present no risk unless handled - contain sources with significant levels of activity and therefore present exposure risks for the people coming into contact with them, during their removal for example.

Furthermore, experience has shown that the containment of radioactive sources can deteriorate over time, thereby increasing the radiological risks when the lightning arrester is removed. The removal operations must therefore be carried out by specialist companies and be directed towards the disposal routes established by ANDRA.

ASN wants to see the progressive and organised recovery of these radioactive lightning arresters, and for several years now has been informing the professionals to ensure that their removal guarantees compliance with radiation protection requirements for the workers and the public. ASN has stepped up its action in this respect since 2009, by reminding the professionals of their obligations, particularly that of having an ASN license for the activity of removing and storing the lightning arresters pursuant to Articles L.1333-1, L.1333-4, and R.1333-17 of the public health code.

In parallel with this, ASN conducted on-ground verifications of the companies involved in the recovery of these objects in 2012. ASN's verifications in this area will be stepped up in 2012.

Additional information on radioactive lightning arresters is available on the following web sites:
– *www.paratonnerres-radioactifs.com/*
– *www.andra.fr/*

Light bulbs containing small quantities of radioactive substances

Certain light bulbs, chiefly very high intensity discharge lamps used in public places or professional environments, and in certain vehicles, contain small quantities of radioactive substances (krypton 85, thorium 232 or tritium). These substances serve to increase the light intensity or facility illumination of the lamps. Addition of these radioactive substances has been common practice for several decades.

On the basis of technical assessments demonstrating their very low impact in terms of radiation protection, several European countries have exempted these objects from the licensing or notification system provided for by the European regulations relative to radiation protection . Other countries, such as France, are currently assessing the technical reports available on this subject.

ASN has taken up this issue since 2009, reminding the manufacturers concerned by the production and distribution of light bulbs that the intentional introduction of radionuclides into

Cutting off the head of a lightning arrester

consumer goods is prohibited in France by the public health code. To put their situation in order, the manufacturers have lodged files with the DGPR (General Directorate for Risk Prevention), applying for a waiver to this prohibition. These files were transmitted to ASN on 19 October 2011 and are currently being examined.

ASN is also taking part in international think tanks in this area (see information note published in July 2011 further to the seventh meeting of HERCA: *www.asn.fr*).

2|5 Reinforcement of the regulation of electrical devices generating ionising radiation

ASN wishes to supplement the provisions introduced into the public health code in 2007, and thus complete the development of the regulatory framework allowing the distribution of electrical devices for generating ionising radiation to be subject to licensing in the same way as the suppliers of radioactive sources. Experience shows that in this respect, the joint technical examination of files by ASN and the device suppliers/manufacturers brings substantial gains in radiation protection optimisation (see point 2 | 1).

For electrical devices used for non-medical purposes, there is no equivalent of the medical CE marking confirming conformity with several European standards covering various fields, including radiation protection. Furthermore, experience feedback shows that a large number of devices do not have a certificate of conformity to the standards applicable in France. These standards have been obligatory for many years now, but some of their requirements have been partly obsolete or inapplicable due to the lack of recent revisions.

Back in 2006, ASN contacted the Ministry of Work, the LCIE (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 led a revision process for the NF-C 15-160 standards, and the associated specific standards (installation standards), which led to the approval of a new standard in February 2011. ASN took part in this work and is preparing the regulatory modifications necessary for it to be taken into account.

With regard to the design of the devices, ASN is looking into the development of the applicable technical requirements to license the devices. After presenting the first orientations to the GPRAD in June 2010, ASN continued its work with the support of the IRSN and the assistance of other reference players such as the CEA and the LCIE, with a view to developing a baseline technical standard for this type of device. The results of the technical work were presented to the GPRAD in December 2011.

Similarly to the ASN decision 2008-DC-0109 relative to the distribution of radioactive sources, ASN is working on a draft decision to define the detailed content of the information that must be enclosed with the initial applications for a license to distribute X-ray generators. The lack of a relevant baseline technical standard at both national and international level, obliges the integration of technical design requirements into the envisaged licensing process, while ensuring their compatibility with the European regulations.

The results of the work entrusted by ASN to the IRSN, the Veritas Bureau, the LCIE and the CEA, should enable the required technical characteristics of X-ray generators with respect to the radiation protection requirements for the users and the public to be defined.

2|6 Detection of radioactivity in France

ASN considers that the increase in the number of cases of detection of radioactivity in metals and consumer goods across the world is worrying. Noteworthy recent findings include:
– an accident that occurred in April 2010 on a metal recycling site in India, and was rated level 4 on the INES international radiological events scale;
– the discovery in July 2010 in the port of Gênes Voltri in Italy, of a container displaying a dose rate on contact of 600mSv/h, originating from Saudi Arabia;
– several cases of triggering of radiation portal monitors in Belgian ports by containers being shipped to France, reported by the AFCN (Federal Agency for Nuclear Regulation), ASN's Belgian counterpart. Triggering was caused by contaminated consumer goods (bathroom tap kits contaminated with cobalt 60, laundry balls, etc.) or naturally radioactive substances coming from China (tourmaline powder containing natural radionuclides, intended for the impregnation of fabrics).

Utilisation of an X-ray generator on work site

At present, the French regulations concerning the movements of goods at the French borders do not provide for specific checks to search for radioactive materials. The detection of radioactivity at the borders allows the detection of the arrival on European territory of consumer goods contaminated by radioactive substances. It is also a means of combatting nuclear terrorism, insofar as it makes it more difficult to illegally introduce into France radioactive material that could subsequently be used for malicious purposes.

Furthermore, the post-Fukushima situation has demonstrated the value of radiation portal monitors for checking the radiological quality of trade flows following a nuclear accident.

In the light of this experience feedback, ASN has strengthened its contacts with the administrations concerned by this domain, and with its European counterparts, notably by participating in a European conference aiming at sharing good practices in radioactivity detection in strategic places (ports, airports, etc.). ASN effectively considers that France must rapidly adopt a national strategy for radioactivity detection on its territory, and make the corresponding investments in equipment and training.

2|7 Implementation of a system for monitoring 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 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 decided to entrust ASN with the role of regulating the security of radioactive sources, in other words to monitor the prevention of acts of terrorism concerning these sources.

The legislative process initiated by the Government in 2008 with the aid of ASN has not been concluded to date. It is necessary for France to adopt legislative provisions on the protection of sources against malicious acts in order to meet its international commitments.

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.

3|2 The main incidents in 2011

A full run down of radiation protection events in the domain, excluding BNIs, is presented in chapter 4. The following two events gave rise to in-depth experience feedback in 2011.

Level 2 incident occurring while using a gamma ray projector on the premises of STIC, a company located in Rambervillers (Vosges département[2])

The incident occurred on 22 September 2011 and involved a gamma ray projector (an industrial radiographic inspection device) used on the premises of STIC, a company situated in Rambervillers (Vosges *département* - 88), during a weld inspection performed by the LEM (Montereau Test Laboratory).

A metal part fell onto the guide tube, deforming it and preventing the radioactive source (iridium 192 of 500 GBq) from retracting to its safe shielded position inside the device. The operators established a safety perimeter to avoid any risk of exposure of the public.

The emergency services and two ASN inspectors went to the site to check that this safety perimeter had been properly set up and that the area was under due surveillance.

The installation of leaded blanket shielding around the source enabled the safety perimeter to be reduced to one portion of the building on Friday 23 September 2011. ASN asked LEM to ensure that the areas was kept under surveillance and to define, through consultation with specialised companies, the necessary measures to retrieve the source.

At the request of LEM, Cegelec - the company that supplies the gamma ray projectors of this type in France - performed a borescope inspection of the guide tube to identify the exact causes of the blockage and define an intervention protocol. The inspection results led Cegelec to design and develop a specific tool to straighten the guide tube and release the source. The intervention, which was subject to a prior technical examination and authorisation by ASN, was successfully carried out on site by the Cegelec technicians on 24 November 2011. The doses received by the operators during the intervention (0.007mSv maximum), were below the dosimetric predictions established beforehand (0.05mSv) and well below the annual regulatory limit set for workers (20mSv).

This event caused no radiation exposure for the public.

Analysis of the incident showed that an operator from LEM attempted to unjam the source by intervening manually on the damaged device on 22 September. The intervention consisted in manipulating the guide tube on either side of the assumed position of the source.

Owing to the very short duration of the operation, the operator exposure, estimated at 1.5 millisievert (mSv), is below the annual exposure limit set by the regulations (20mSv). An additional evaluation of exposure of the hands was carried out at the request of ASN by the IRSN, its technical support body. This evaluation did not reveal a risk of the operator suffering irreversible effects.

Even though the intervention lasted a very short time, this manual manipulation in the immediate proximity of a high-activity source is contrary to the rules of radiation protection. Consequently, ASN rated this event level 2 on the INES scale, which comprises 8 levels, from 0 to 7.

Follow-ups to the Feursmetal incident in Feurs (Loire département)

On 26 May 2010, six people from Feursmetal, Cegelec and the IRSN, and premises and items of tooling of the Feursmetal foundry were contaminated during an attempt to retrieve a high-activity (1.25 TBq) cobalt 60 radioactive source that was jammed in the guide tube of a gamma ray projector. The gamma ray projector and the jammed source had been jammed since 7 May in a bunker on the Feursmetal site where the projector was regularly used to inspect castings.

Although the human consequences turned out to be limited (dosimetric impact on the workers evaluated at between 0.2mSv and 0.6mSv, depending on the person), the material consequences were considerable, since significant contamination was measured in the bunker, the adjacent premises, and certain peripheral areas internal to the company, affecting the casting moulds necessary for the fabrication of parts.

The first decontamination phase targeting the moulds and the areas in the periphery of the bunker, which began in 2010, was continued in 2011 in compliance with the prefectural order of 22 June 2010 that provides the regulatory framework for this decontamination work.

Thus, all the moulds necessary for production were decontaminated. Besides this, ASN and the Rhône-Alpes region DREAL (Regional Directorate for the Environment, Planning and Housing) delicenced the section of the road within the company that had been affected by the contamination, in the light of the inspection reports drawn up further to the decontamination work. Lastly, studies have been started with a view to launching the works concerning the most seriously affected areas in 2012, namely the gamma radiography bunker and the adjacent premises.

ASN rated this event level 2 on the INES radiological events scale.

2. Administrative region headed by a *préfet*

4 ASSESSMENT OF RADIATION PROTECTION IN THE NON-MEDICAL SECTOR AND 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.

Industrial radiography

The recent gamma radiography incidents that occurred in 2010 and 2011 in France (Feursmetal, Hachette & Driout, Rambervillers) brought home the importance of radiation protection in industrial radiography activities. Over and beyond the health risks for the operators, the economic consequences of accidents can be very considerable.

The work conditions on the site (poor accessibility, night work, etc.), equipment maintenance (projector, guide tubes, etc.) are major factors affecting personnel safety. The incidents often result from sources getting jammed outside the safe shielded position. ASN notes that the exposure rates and condition of the equipment are not unrelated to the probability of an incident. It moreover underlines that if any equipment operating anomalies are observed, such as abnormal source projection or retraction forces, operations should be immediately stopped and the equipment inspected. Furthermore, if a source gets jammed, no attempts should be made to release it, and the on-site emergency plans required by the regulations - though rarely drawn up - must be implemented.

Beyond the incidents noted, ASN considers from its inspections that the way risks are taken into account varies between companies. 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 contractors to enhance work preparation and allow the application of effective preventive measures.

Static X-ray generator in a workshop

After considering the questions of justification and optimisation, the non-destructive testing professionals have drafted guides, including a guide for companies seeking an alternative to iridium 192 for the gamma radiography inspection of pipe fabrication welds (ALTER'X, coordinated by the French Welding Institute), and a guide coordinated by COFREND, promoting the use of alternative methods and including functional tools such as a flow chart for identifying the gamma radiography substitution conditions, and matrices describing the inspection and its objectives.

ASN considers that the involvement of the ordering customers is vital to make progress in radiation protection in industrial radiography.

The regulation and monitoring of industrial radiography is a priority for ASN, with 114 inspections carried out in 2011, some in collaboration with the labour inspectorate. This priority is maintained in 2012.

Enhancing the awareness of all the players is also a priority. Regional initiatives to establish charters of good practices in industrial radiography have been underway for several years at the instigation of ASN and the labour inspectorate, particularly in the Provence-Alpes-Côte d'Azur, Haute-Normandie, Rhône-Alpes, Nord - Pas-de-Calais and Bretagne/Pays de la Loire regions. These initiatives allow regular exchanges between the various stakeholders and are therefore going to be continued. The ASN divisions and other regional administrations concerned also organise regional awareness-raising and discussion symposia which are attracting growing interest from the stakeholders of this branch.

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.

In 2011, ASN established contacts with the nine health and safety at work inspectors of the Ministry of Research in order to discuss inspection practices and look into reciprocal methods of exchanging information to improve the effectiveness and complementarity of the inspections. An agreement should be drawn up in 2012 between ASN and the general inspectorate of the Ministry responsible for research and higher education.

Veterinar

The administrative situation of the veterinary structures is improving (1,527 structures notified and 349 licensed at the end of 2011), but is not yet satisfactory. The inspections carried out in 2011 showed that the work of the national professional institutions in the field of radiation protection, leading to the drafting of guides and good practices sheets, is not uniformly applied in the field. The radiation protection technical inspections, the workstation studies and risk analyses must be improved. In the last few years ASN has nevertheless seen progress in the employment of persons competent in radiation protection, in dosimetric monitoring and in the wearing of personal protective equipment.

ASN will continue its inspection actions in 2012, with a view to putting the administrative situation of all the players in order and improving their radiation protection practices, particularly in the equine sector. These inspections will enable the effectiveness of the recommendations and good practices issued by the national professional institutions to be judged on the ground.

Removal of lightning arresters

The removal of old lightning arresters containing radioactive sources is an activity requiring strict radiation protection measures (see point 2 | 2 | 2). ASN has planned to reinforce the inspections in this area in 2012 to ensure that the professionals exercise their activities in compliance with radiation protection regulations and good practices.

Suppliers of ionising radiation sources

As stated in point 2 | 3, ASN considers that the regulatory oversight of suppliers of electrical ionising radiation generators is still insufficient, given that the technical characteristics of the devices put on the market are of prime importance for the optimisation of the exposure protection of their users. The work conducted by ASN in this area should enable a decision setting the technical requirements for the devices distributed in France to be established in 2012.

ASN inspection of a gamma radiography work site at Roissy airport – February 2012

ASN is also stepping up its inspections in radiopharmaceutical research and production using cyclotrons. The 27 cyclotrons existing in France, which are subject to licensing by ASN, have strong radiation protection implications and display high technical complexity. Eleven inspections are planned in this area in 2012.