RADIATION PROTECTION OF THE WORKERS IN INDUSTRIAL RADIOGRAPHY : THE POINT OF VIEW OF THE REGULATORY BODY IN FRANCE

-*-*-*-*-*-*-*-

Alain BIAU
OPRI (Office de Protection contre les Rayonnements Ionisants)
Deputy Medical Director

Industrial radiography carried out with X ray generator (settled units) or sealed gamma ray sources of Cobalt 60 or Iridium 192 (settled, mobile or potable units) is used in different fields of non destructive control : nuclear, automobile, naval industries, equipment, or fine arts.

Settled units don't generate major problems in radioprotection. On the contrary, gammagraphy with portable units may lead to more important level of exposure and presents potential risks of accident.

The table 1 shows the distribution of annual doses registered in 2000 among the operators of industrial radiography monitored by OPRI, « Office de Protection contre les Rayonnements Ionisants », organism governed by the Health and Labour Ministries.

TABLE 1 - DISTRIBUTION OF ANNUAL DOSES IN INDUSTRIAL RADIOGRAPHY IN FRANCE IN 2000

	Number of workers	Class of dose (millisievert)							Collective dose (man.Sievert)
		< 0,2	0,2 - 1,0	1,0 - 6,0	6,0 - 15	15 - 20	20 - 50	> 50	
Gammagraphy	565	517	20	14	3	0	10	1	0,72
X. ray radiography	1058	1038	18	2	0	0	0	0	0,011

These data show that for a number of workers lower than the half the collective dose is seventy times higher in gammagraphy than in X ray radiography. It is also in the field of gammagagrphy that we can observe 11 cases of annual doses over the limit of 20 millisieverts (European Directive 96/29 of 13/05/1996).

The gammagraphy was also at the origin of dramatic accidents with serious consequences and in several cases, the death of the victims.

We must remember among the most known, the accident of Setif (Algeria) in 1978 where 20 persons were irradiated with an Ir 192 source of 0,9 TBq. Six persons were treated in the Curie Institute of Paris and one is dead.

In 1984, in the neighbourhood of Casablanca (Morocco), 8 members of a family died after being exposed, during a few weeks, by a source (1,0 TBq of Iridium 192) of gammagraphy recovered by a worker and layed down on a table of the family bedroom.

More recently, in June 2000, in Egypt, two persons died after being in contact with a source of gammagraphy.

The french authorities have had always a special attention to the risks related to industrial gammagraphy.

The purpose of this paper is to describe the incidents which occurred in France during the past 25 years. After, we shall present the mean aspects of the french reglementary dispositions to control this practical and to reduce the risks for the users and the public.

At last, we shall propose, some ideas to improve the radiological protection of the workers to carry on this practical very useful and essential for the security in the different fields where it is used.

I - STATE OF THE INCIDENTS OR ACCIDENTS IN FRANCE FROM 1975 TO AUGUST 2001

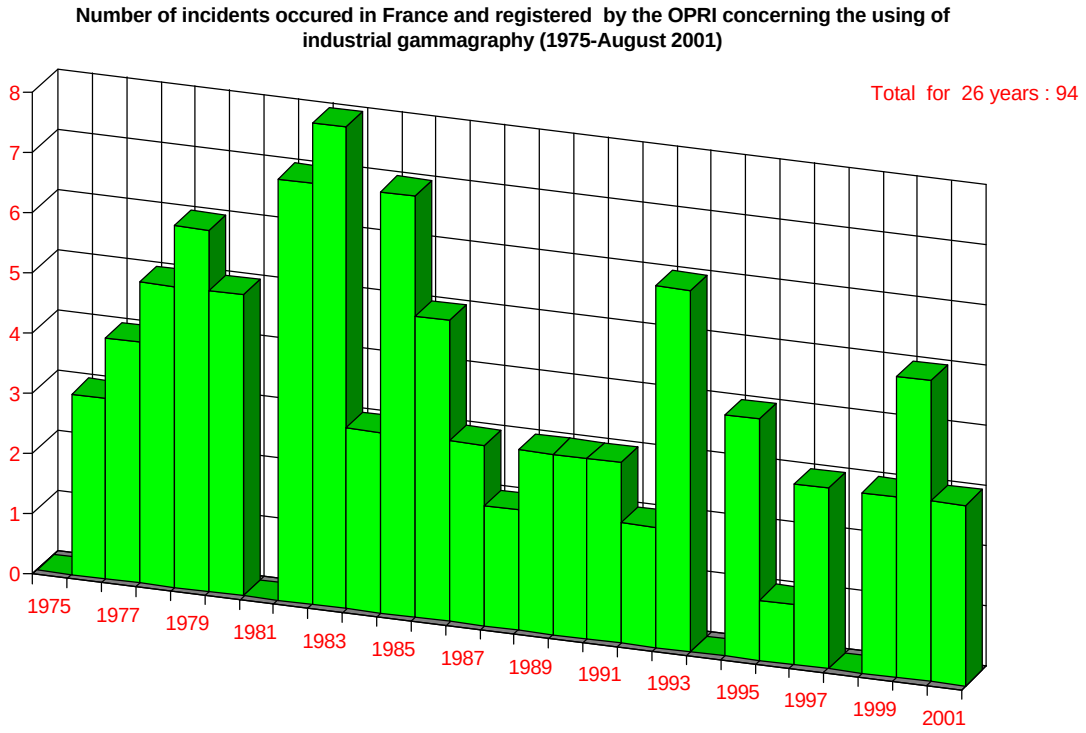
The risks are related to the high levels of irradiation when the sources are pulled out of their protective containers.

An example a source of 1 TBq of Iridium 192 delivers at 10 m. a dose rate of 0,022mGy per minute which represents a low level of exposition for a person who would go across the perimeter of security. The same source delivers 2,2 mGy by minute at 1 m, that is the level of doses potentially received by the operators when they are not very scrupulous with safety rules. It is a high but not catastrophic.level . But at 1 cm the dose rate of 22 Gy per minute would producedramatic exposures within a few minutes..

We can distinguish two categories of incidents :

- Incidents resulting of misuses or breakdown of the device
- Loss or robbery of sources or transport incident

In the first category, 94 incidents have been pointed out to OPRI from 1975 to august 2001 (see figure below) **:**



All of these incidents formed the subject of dosimetric controls from OPRI. For 16 of these incidents,exposures were in the order or above the regulatory limits and 13 lead to medical care at the Institut Curie of Paris.

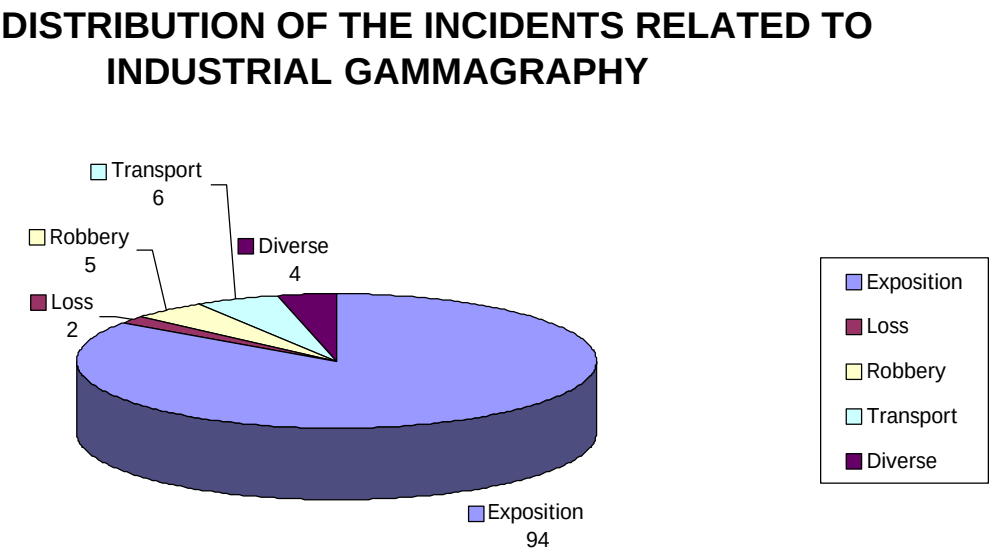
The origin of these incidents was the presence of the workers more or less near the source without protection device. It may result from a misfunctioning of the system of withdrawal of the source toward the protective container. In several cases, the source is broken away of the transfer cable and the process of recovery of the source leads to exposure of the operators. In other circumstances, it is a lack of coordination between the operator who put in place the films and the other operator who take out the source.

In the second category, loss or robbery of sources and transport incidents, 17 cases have been registered during the same period. They didn't lead to dangerous exposures because in all these cases the source remained confined in the protective device. However, this kind of incident can have serious consequences if the source were pulled out

the container and were taken by a person keeping this source without protection during several hours such as the dramatic situations quoted at the beginning of this paper.

One other risk is that the equipment with the source be smelted in scrap-iron recovery factories and that radioactivity be present in steel like Cobalt 60 found in watches in novembrer 2000 in France and in axes of rubbish lorry in June 2001.

The figure below shows the distribution of the incidents for the different situations defined above.



II - THE FRENCH REGULATIONS

The french regulations concerning gamma ray radiography,are related to 4 items:

- The radioactive source
- The apparatus
- The workers
- The transport of the source

II.1 - THE RADIOACTIVE SOURCE

The « Commission Interministérielle des Radioéléments Artificiels », C.I.R.E.A., is the regulatory body which delivers licences for being in possession of radioactive sources for use in gammagraphy. These sources are Iridium 192 (highest activity authorized 3,7 TBq) and Cobalt 60 (highest activity authorized 0,74 TBq).

The authorizations are delivered to the companies after a study of a record which must show the competences and the means of protection. These authorizations are associated to strict consigns of using.

The C.I.R.E.A. has an other important mission which is the tracability of the sources. Each authorization and each source are identified by a number and the source is followed over years from the delivery to the final setting in the french regulatory radioactive waste (ANDRA).

Every loss or robbery of sources must be declared to C.I.R.E.A. and when the source after decreasing is not usable it must be returned to the manufacturer of the apparatus.

In 2001, about 600 gammagraphy units are registered in about 200 companies.

II.2 - THE APPARATUS

All the device in which the source is used must be in agreement with the european norms but its caracteristics on the fields of protection, security and maintenance must respect the regulations of two principal texts, the decree 85-968 of August 27th, ,1985 which defines « hygien and security conditions to which the industrial gammagraphy apparatus using gamma radiation must satisfy » and the decision of October 11th ,1985 which fix the contents of the documents required to the application of the decree of August 27th ,1985.

This decree involves a set of constraints in terms of radioprotection and the limits levels of dose rate when the source is in storage position (see table 2 below) and in case of shock, the security devices about the projection channels, the cable of ejection, the device of remote control, the protection against sand, water, dust,…, the devices about the source itself and its protection (special tool for unsetting the apparatus, locking to resist to burglary different for every apparatus, design of the different components to avoid eventual intempestive breaking away). A visual signalling concerning the position of the source is prescribed (see table 3 below).

TABLE 2 -LIMITS OF DOSE RATE AROUND A PROJECTOR OF GAMMAGRAPHY (DECREE OF 27/08/85)

Type of projector	Dose rate in air (mGy/h)			
	Contact maximum value	To 5cm from the walls of the projector	To 1 m from the walls of the projector	
	maximum value	maximum value	mean value	maximum value
Portable	1	0,5	0,02	0,1
Mobile	2	0,5	0,02	0,1
Fixed	2	1	0,02	0,1

TABLE 3 - VISUAL SIGNALLING (decree of 27/08/85)

All the source holder in storage position : complete and locked obturation	green signal
All the source holder in storage position : complete but non locked obturation	yellow signal
No complete obturation : source holder in storage position or no	red signal

Moreover informations upon the apparatus must appear on an unremotable sticker (name and address of the manufacturer, name and address of the importer, year of fabrication, identification of the projector, maximal activity of each radionuclide authorized in this projector).

An other sticker, strongly fixed must demonstrate the chemical symbol and mass number of the radionuclide, the activity , date and registering number of the source.

An instruction notice set by the manufacturer and specifying the conditions of handling, setting, using and keeping in good order and the safety procedures.must be joined to each apparatus. .
At last, one document must contain all the procedures to satisfy the conditions described above. The content of the document is precisely defined in the decision of october 11th ,1985.

All these regulations permit to avoid apparatus dangerous by their conception or out of order.

In many cases, it is the bad state of mechanical pieces which led to the fall of the radioactive source with the associated risks for one person who would take the source in his hand.

II.3 - THE WORKERS

Regulatory texts related to workers concern training and monitoring of exposure

➔The training is defined in the decree of June 25th ,1987 entitled « Certificat d'aptitude à manipuler les appareils de radioscopie industrielle et de radiographie industrielle (CAMARI) .

CAMARI certificate is delivered by a jury formed by the Regional Director of Work and Employment, a physician specialized in labor medecine and one person chosen for his knowledge in radioprotection.CAMARI certificate is delivered upon oral and written examinations on the following items :
general notions on the ionizing radiations, the interactions of ionizing radiations and the matter, biological actions of radiations, the regulation in the field of protection against ionizing radiations., the systems of measurements (dosimeters, radiameters), the basic concepts of radioprotection (distance, shielding, dose rate and time of exposure…).

For the particular use of gamma ray sources, the program includes basic notions on the nature of radionuclide, the definitions of activity, period, radiation specific constant, and the using of decreasing tables.

At last, the tests concern also the knowledge of the different types of apparatus and of the principal items of the decree of August 27th 1985, of the regulations about using radioactive sources and their transports and the procedures to follow in case of incident.

➔The monitoring of exposure is defined by the decree of 02 october 1986 modified by the decree of 24 december 1998 and the decrees of 23 march 1999 concerning the procedures for using dosimeters active and passive and transmission and consultation of the dosimetric data on national data base held by OPRI.

A new decree is being prepared to fulfill the European Directive 96/29 requirements and will be published in the next months, it will be not different, on the principal items, from the actual decrees except for the annual limits of dose wich will be low from 50 to 20 millisieverts for the workers of category A and from 5 to 1 millisievert for public members.

The gammagraphy operators are classified in category A and are monitored by passive dosimeters. The active dosimeter (electronic dosimeter) is also obligatory since the 1st January 2000 but all the workers don't wear this kind of dosimeter so far .

II.4 - TRANSPORT

The transport of gammagraphy apparatus with their sources of gamma ray radionuclides is in the field of the general regulation about the transports controlled by the « Direction de la Sûreté des Installations Nucléaires », D.S.I.N. The transport presents two aspects :

- the transport from the manufacturer to the company authorized. This one is assured by specialised societies and doesn't raise any problem.

- The most critical transport is those that is achieved by the operator himself, in general in his own vehicle, who travels from a site to another. This kind of transport gives rise to risks of robbery. In a first time it is the vehicle which is the object of robbery and after, when the robbers understand that there is a radioactive source in the apparatus, they leave it anywhere. An other risk is road accidents and in this case even if the apparatus remains undamaged, its presence can lead to all kinds of reactions from the persons who must approach for interventions.

III - PROPOSALS FOR IMPROVING THE SECURITY

All the regulating body described above has permitted to avoid accident of great importance since the last 25 years in France exception of a few accidents leading to exceed the dose limits, and especially for one worker suffering of serious physical damages in Montpellier in 1979.

It is possible however to improve the security by reinforcing the following points :

III.1 - TRAINING AND MONITORIG OF THE OPERATORS

The training of gammagraphy operators is sufficient However if it would be desirable to set up a control of knowledge more frequently, the time of validity of CAMARI certification being 9 years nowadays,and to reinforce the continuing training of workers in their companies.

As we have seen, in the first chapter, the individual doses received by gammagraphy workers are not negligible and the best way to reduce them is to systematically use active (electronic) dosimeters

On this subject, it is possible to improve these dosimeters essentially the system of alarm because it happens, in hostile environment such as in reactor building of a nuclear plant, the sounding alarm may be lower than the ambiant noise or the lighting alarm may not be perceptible, the dosimeter being located under the protective clothing. We can imagine a vibrating alarm and, why not, the transmission in real time, of the dose measurements to another operator who follows the operation.

And on point of view of Medical survey, it is necessary to be sure that the operator has a good health with a good physical and psychological strength for the gammagraphic operations are very often achieved on the night in very particular conditions which can generate loss of control in relation with tiredness and poor concentration. It is also important that gammagraphy operations will be achieved by teams of two or three persons for security reasons.

III.2 - TRANSPORT OF RADIOACTIVE SOURCES

We have seen in the precedent chapters that the transport of gammagraphy device from a site to an other site by the operator represents the most important potential risk. For example in France, near Roissy Airport, in March 1999, a vehicle transporting a gammagraphy apparatus and its source was robbered on a parking place and the key of security of the device was remained with the apparatus in the vehicle. This key should have been kept by the operator but he didn't. Fortunately, this source was recovered in Belgium in a steel factory without damage for anybody. It is important to be more and more strict in this field.

Moreover we could imagine a system of marks included in the body of the apparatus (transmitting device) permitting its localisation in case of robbery.

CONCLUSION

In conclusion, the absolute respect of all the regulation in place in France has allowed to limit the number of accidents related to the practice of industrial gammagraphy .It remains by its facility of using, a system of non destructive control unequaled in a large number of circumstances, even if it will be preferable, when it is possible, to adopt an other practical without sources of ionizing radiations.