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TRANSPOSITION OF ICRP–60 RECOMMENDATIONS INTO FRENCH URANIUM MINING REGULATION

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Abstract

Directive 96/29/Euratom, drawn up from recommendations of the ICRP 60, must be transposed into French legislation before 13 May 2000. For the French uranium mining sector, two ministerial decrees, one for workers, the other for the environment, must be modified to take account of the new European rules. These modifications entail new statutory limits either for the workers, or to characterise the radiological impact on the environment. For the workers, the implementation since 1980 of a policy of optimising radiation protection in French mines enables us to envisage that these limits will be respected. For the environment, the application of new limits involves a new approach for the assessment of public doses, with the precise definition of critical groups and their realistic exposure scenario.

1. INTRODUCTION

The recommendations of the ICRP 60 were used by the European Community to draw up the 96/29 EURATOM directive, fixing the basic standards relating to the protection of the health of the population and of the workers against the dangers resulting from ionising radiation.

This directive must be transposed into French legislation before 13 May 2000. An interministerial committee was established by the Prime Minister of France to prepare this transposition, which involves extensive revision of existing texts, including those which govern the radiological monitoring of workers and of the environment of uranium mining sites.

This interministerial committee includes the seven ministries concerned, which are Health, Employment, Industry, the Environment, Transport, Research and Agriculture.

A technical steering committee assisted by groups of experts is responsible for drawing up drafts of texts to be submitted to the Interministerial Committee which will decide the option to be retained in the texts.

At the present time, the architecture of the texts associated with the transposition of Directive 96/29 is being organised into a structure composed of five general texts stating the principles of protection against ionising radiation, the protection of workers and the protection of the population, the accidents and emergencies and the administrative procedures, as well as more specific ministerial decrees in certain fields such as the mining sector.

2. THE RADIOLOGICAL MONITORING OF WORKERS IN THE MINING SECTOR

2.1. Existing regulations for French uranium mines

The recommendations of the International Commission of Radiological Protection (ICRP N°. 26 and derivative publications) which were adopted by the European directives of 15th July 1980 and 3rd September 1984, were adopted into French legislation by a ministerial decree

(decree N° 98–502 of 13th July 1989) introducing requirements for the protection of workers against ionizing radiation into the Mining Code.
This regulation has been in force since 20th January 1990 in all French underground and open-pit mines and their associated mills.

The main technical characteristic of this regulation is that the exposure monitoring of personnel and the monitoring of the radioactive atmospheres at the work stations are handled using specifically laid down procedures and equipment.

For personal exposure monitoring, the French regulation requires the following systems to be implemented:

(a) individual dosimetry for workers likely to be subjected to an annual dose greater than 3/10th of the statutory limit;
(b) function dosimetry for checking operators likely to be subjected to an annual rate of exposure between 1/10th and 3/10th of the statutory limit.

Operators likely to be subjected to annual exposure of less than 1/10th of the annual limit are considered not to be exposed to ionizing rays and are not monitored. It is only necessary to check the working environment in order to ensure that the 1/10th of the statutory limit is respected.

These are the requirements applicable for radiological surveillance of French uranium miners [1]:

(a) individual dosimetry for operators working in underground mines, based on the use of equipment worn by operators during their working period enabling continuous measurement, during one month of the exposure to which each worker is subjected;
(b) function dosimetry for operators working in open-pit mines or mills, based on the use of equipment worn by a sample of workers representing different functions occurring in the operation concerned.

About the statutory individual limits, in uranium mines or mills we are in the situation of combined internal and external exposure, as the miner receives doses due to gamma rays (external exposure) and inhaling radioactive aerosol alpha transmitters (internal exposure) by mineral dust and short-lived radon decay products.

In addition, an annual limit taking into account the combined risks must be respected. For each worker, we must calculate the following formula:

$$TER = \frac{\gamma}{50\ mSv} + \frac{PAE\ Rn222}{20\ mJ} + \frac{PAE\ Rn220}{60\ mJ} + \frac{LLAE\ ore}{1700\ Bq\ alpha} + \frac{LLAE\ U}{30\,000\ Bq\ alpha}$$

with:
Gamma = the annual dose of external exposure in mSv,
PAE Rn222 and PAE Rn220 = potential annual inhaled alpha energy from short-lived decay products of radon 220 and 222 isotopes, in mJ,
LLAE = total activity of long-lived alpha emitters of the uranium chain, inhaled annually in Bq (ore or concentrates).

This formula is called the Total Exposure Rate "TER".

The limit of TER is 1 for 12 months running. The value of TER = 1 is equivalent to an effective dose of 50 mSv (with ICRP 32 and 47 dosimetric conversion coefficient).

2.2. The transposition of the European Directive for uranium mines

European directive 96/29 Euratom, recommends for occupational exposure a new limit on effective dose of 100 mSv in 5 years, not exceeding 50 mSv in any single year.

A new formula for the Total Exposure Rate would need to be taken into account, as follows:

$$TER = \frac{Hp}{50\ mSv} + \frac{PAE\ Rn222}{42\ mJ} + \frac{PAE\ Rn220}{127\ mJ} + \frac{LLAE\ ore}{5400\ Bq\ alpha} + \frac{LLAE\ U}{27\ 000\ Bq\ alpha}$$

This TER should be lower than 2 over 5 years, not exceeding 1 per year.
This value of TER = 1 is here equivalent to an effective dose of 50 mSv.
The following equivalencies are considered here (Ref.: Annex III of the European Directive):

(a) for PAE Rn222 : 1.4 mSv ≡1 $mJ.m^{-3}.h$ or 50 mSv ≡ 42 mJ
(b) for PAE Rn220 : 1.1 mSv ≡ 1 $mJ.m^{-3}.h$ or 50 mSv ≡ 127 mJ
(c) for the uranium ore : $9.35.10^{-3}$ $mSv.Bq^{-1}$ alpha.

We consider here the whole of the long-lived alpha emitters of the uranium chains, assumed to be in radioactive equilibrium with an average lung clearance type M, an AMAD of 5µm and we suppose that no short-lived alpha emitter remains on the filter having sampled the aerosol inhaled.

— for the uranium concentrates dusts : $1.85.10^{-3}$ $mSv.Bq^{-1}$alpha.

With AMAD = 5 µm and a lung clearance type M.

The graphs in Annex I present the dosimetric situation of the underground mine and the processing plant of the Jouac Mining Company, the only mine in operation in France at the present time.

We can see that for the year 1997, the maximum effective dose recorded is equal to 15.8 mSv (i.e. a TER = 0.316) and that the average dose is equal to 6.5 mSv for the underground mine workings and 3.7 mSv for the processing plant.

We can therefore think that the implementation of the new regulations from the ICRP 60 ought not to introduce any discontinuity into the practice and results of the radiological monitoring of uranium mines in France. In fact, the efforts in risk prevention carried out by the mining company from 1984 up to now can guarantee that the new individual limits will be respected.

Unfortunately, when this new regulation comes into force, it will doubtless be difficult to see the result of these efforts inasmuch as French underground uranium mines, faced with the very depressed economic climate in the market for natural uranium, are doomed to disappear as the year 2000 approaches.

However, after the mining operations cease, there remains the problem associated with the environment and the radiological impact of the installations after they have been dismantled and the site reclaimed. It is on this second phase that the statutory constraints associated with the application of the recommendations of the ICRP 60 must now be analysed.

3. EVALUATION OF THE IMPACT ON THE ENVIRONMENT OF THE EXTRACTION INSTALLATIONS AND URANIUM PROCESSING PLANTS

3.1. The existing context of French regulations

Extraction and uranium ore processing operations significantly modify the natural radioactivity of a region, characterised in the beginning by important anomalies of uranium concentrations in the geological surroundings, at a relatively shallow depth and sometimes showing on the surface, but generally without any significant radiological impacts on the populations.

The transfer conditions of the associated radionuclides can be disturbed, notably in the neighbourhood of the surface storage of mining waste and solid processing tailings. For the local populations, this can result in an additional exposure to ionizing radiation according to different possible ways of transfer. A system for limiting the radiological risks caused by this additional exposure is necessary.

Since such a system will be dealing with chronic long-term exposure of low dose rate equivalent, and with no risk of accidental exposure to high doses, it can be based simply on the limitation of the annual dose equivalents of the population. However, this limitation requires a plan of action to confine the radionucleids at their sources of potential emission and to purify any possible liquid and gaseous waste. The effectiveness of these measures must be clearly demonstrated by a monitoring network of the releases, the environment and the exposure of the population.

This system for limiting radiological risks found its statutory expression in ministerial decree N° 90-222 of 9 March 1990, published in the Official Journal of the French Republic on 13 March 1990.

This decree was signed by the Prime Minister and the Ministers of Industry and of the Environment. It incorporates, under the title "*Ionizing Radiation*" of the General Regulations of Extracting Industries instituted by decree N° 80-331 of 7 May 1980, a part relative to the protection of the environment.

It specifies the conditions for the implementation of the radiological monitoring of the natural surroundings around the installations, as well as the constraints imposed on the management of radioactive products (storage of solid products and waste) to be respected by the extracting company. This is to ensure that the individual limits of additional exposure of the population are not exceeded and that the radiological impact on the environment is maintained at as low a level as can reasonably be expected.

For the evaluation of the impact, the ministerial decree N° 90-222 prescribes to calculate for the critical group the value of the following formula:

$$A.T.A.E.R. = \frac{\Delta\gamma}{5\ mSv} + \frac{\Delta PAE\ Rn222}{2\ mJ} + \frac{\Delta PAE\ Rn220}{6\ mJ} + \frac{\Delta LLAE\ ore}{170\ Bq} + \frac{\Delta Ra226}{7000\ Bqalpha} + \frac{\Delta U238}{2\ g}$$

with Δ equal to the different annual exposures due to the mining site with deduction of the initial natural exposure.

A.T.A.E.R. is the Added Total Annual Exposure Rate and must be less than 1 for characterising of an "acceptable impact" with the meaning of the decree.

The value of 1 for the ATAER is equivalent to an effective dose of 5 mSv according to ICRP 32 and 47 recommendations.

Based on field measures, ATAER is evaluated with the following parameters:

(a) time of exposure : 7000 hours per hour,
(b) inhaled flow rate : 0.8 m^3 of air per hour,
(c) drinking water : the only transfer pathway by ingestion, with 2.2 litres per day, with water of river immediately after dilution of releases.

for critical group of the public living in the immediate vicinity of the site.

This standard scenario is unrealistic and leads to over evaluate the public exposure but all the values of ATAER in the vicinity of French uranium sites are under the limit of 1 (or no effective dose of 5 mSv) and all the monitoring results of the networks check compliance with existing regulatory limits.

3.2. The transposition of the European directive

European Directive 96/29 Euratom lays down a limit of 1 mSv for the annual effective dose liable to be received by the public in the environment of an installation.

It also states that the doses resulting from a practice test should be evaluated as realistically as possible for the members of the public who characterise the population critical groups, in all places where such groups may exist and taking into account the effective pathways of radioactive substances towards these populations.

So, in this new context of regulations, the calculation methods used at present cannot be used, for they often consider fictitious people and unreal, extreme exposure scenarios to characterise the critical groups.

Studies are presently being carried out by mining companies to propose to the French authorities a realistic approach for the evaluation of the dose of the public in the environment of uranium mining sites, which would enable the provisions of title VIII of the Directive, describing the implementation of radiation protection for the population, to be respected.
For that, we consider:

Reference group: the members of the public (adult > 17 years) living in the close environment of the site, likely to be the most exposed because they live either down wind or in a low-lying topographical area (valley) or in direct view of the site or downstream of the hydrographical network.

Exposure scenario: exposure time – 7000 hours per year in the area under consideration of which: 3500 hours outdoors; 3500 hours indoors.

Exposure routes:
(a) external exposure outdoors;
(b) internal exposure due to the inhalation of long-lived alpha emitters present in aerosol dusts outdoors;
(c) internal exposure due to the inhalation of short-lived radon decay products, outdoors and indoors;
(d) internal exposure due to the ingestion of radionuclides of the uranium chain (U238, Ra226, Pb 210, Po210, Th230) with drinking waters (1.6 litres per day) and the food chain based on local products (with an annual theoretical consumption of : 30 kg of root vegetables; 20 kg of leaf vegetables; 40 kg of fresh fruit; 20 kg of poultry meat; 10 kg of fish; 70 litres of milk; 20 kg of cheese and butter).

All the exposures are expressed in mSv with the conversion factors given in the Annex III of European Directive.

For the whole of the exposure routes considered, networks of radiological measurements must be put in place to evaluate in a representative manner the radiological levels present. The limit of 1 mSv applies to the effective dose associated with the industrial impact, so the value added to the local natural level must be evaluated. Therefore from the value measured at each monitoring station the value corresponding to the natural level must be subtracted in order to find the contribution of "industrial" origin.

The problem appears easy to solve when a collection of radiological data is available from measurements taken before the work on the site began, and therefore characterising perfectly the natural surroundings to be taken into account for the assessment of the impact.

The problem becomes complicated when initial data do not exist (which is the case in the majority of old existing sites).

So, it appears reasonable to consider that for exposures linked to gamma radiation, to dusts and the ingestion of radionucleids, the natural level should be characterised by measurements carried out by monitoring stations installed in an environment geologically similar to the site under consideration and sufficiently far away to be unaffected by the site.

For exposures linked to radon222 and its decay products, the method which consists of taking a fixed value of the natural level measured in a distant environment to deduct it from the monitoring stations of the critical groups is no longer applicable, since spatial fluctuations of the natural level must be considered which are very often greater than the value of 1 mSv. So, the measuring network put in place must, for each station, enable the "industrial" component to be discriminated from the "natural" component on the value of potential alpha energy measured. It is then only the value of the "industrial" component which must be used to assess the contribution of radon222 to the effective dose of the reference group.

A discrimination method, founded on the differences in isotopic signatures characterised by the relative concentrations of radionucleids of the uranium and thorium chains, has been developed by ALGADE from continuous measurements taken by alpha site dosimeters used in atmospheric monitoring stations [2, 3].

In application of these new procedures enabling the provisions of the European Directive to be applied, evaluations have been made concerning the effective doses of reference groups in the environment of the 2 French mining sites belonging to COGEMA which are presently being reclaimed, (at Bessines-sur-Gartempe in the department of the Haute-Vienne, and at Lodève in the department of the Hérault). These evaluations have shown for the year 1997 levels of dose added to the natural level which are lower than 1 mSv, with the exception of two stations (out of the 15 considered) where the effective added doses are assessed at 1.21 mSv and 1.63 mSv (see Annex II).

These added doses are principally due to internal exposures linked to radon 222 and its decay products (between 60% and 70% of the assessed value).

Insofar as these 2 sites are still being reclaimed, it can be expected that when the final cover of the processing waste storage areas is complete, the levels of exposure associated with radon will decrease and enable the limit value of 1 mSv to be respected for critical groups taking into account.

4. CONCLUSION

For French uranium mining sites, the new statutory provisions which will be in force as of May 2000 in application of European Directive 96/29 Euratom, will bring to light additional constraints particularly as regards the environment and the radiological impact of sites for members of the public.

So, the application of new regulations will require:

(a) a realistic definition of the critical groups and their exposure scenario
(b) a precise definition of the natural background of the site under consideration
(c) a strict methodology for the monitoring of radiological levels in order to guarantee that the measurements are perfectly representative
(d) particular attention as to the choice of instruments for monitoring radon and its decay products in the atmosphere.

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Annex 1

Société des mines de JOUAC (COGEMA Group)

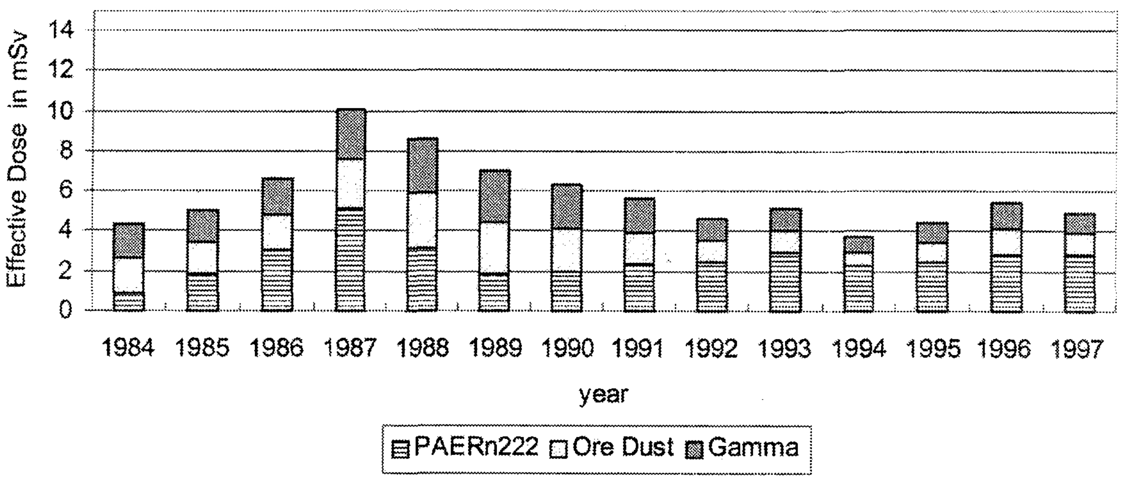
WORKFORCE DISTRIBUTION for 1997

Application of European Directive 96/29 Euratom

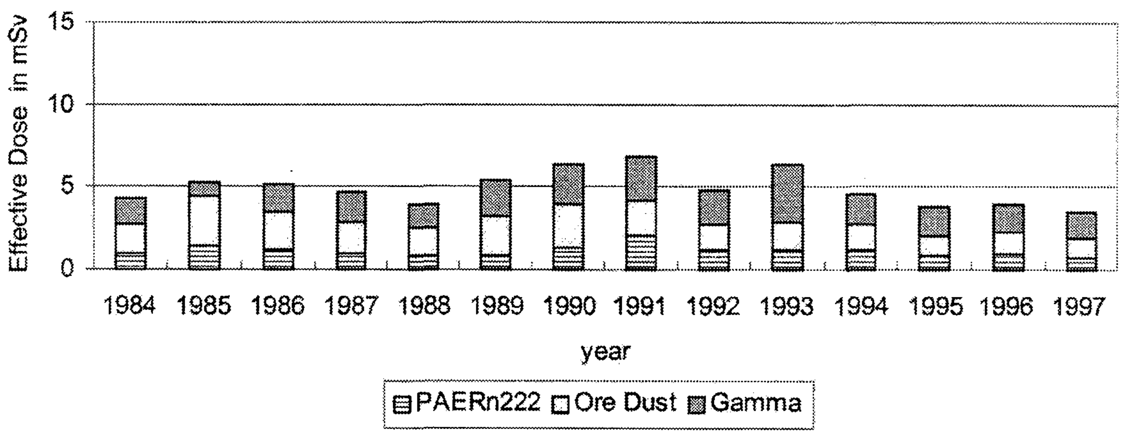
	EFFECTIVE DOSE IN mSv								number of assessed workers	COLLECTIVE DOSE homme.Sievert
	d<1	1≤d<5	5≤d<10	10≤d<15	15≤d<20	20≤d<30	30≤d<50	d≥50		
UNDERGROUND MINE	11	31	21	10	1				74	0,39
TREATMENT PLANT	5	32	2						39	0,11
TOTAL	16	63	23	10	1				113	0,5

$$* \text{ Effective Dose } = 50 \text{ mSv} \times \left[\frac{\text{Gamma}}{50 \text{ mSv}} + \frac{\text{PAE}_{Rn222}}{42 \text{ mJ}} + \frac{\text{PAE}_{Rn220}}{127 \text{ mJ}} + \frac{\text{Ore dust}}{5400 \text{ Bq alpha}} + \frac{\text{Uranate dust}}{27000 \text{ Bq alpha}} \right]$$

EVOLUTION OF ANNUAL AVERAGE EFFECTIVE DOSE
for SMJ underground miners



EVOLUTION OF ANNUAL AVERAGE EFFECTIVE DOSE
for SMJ treatment plant workers



Annex 2

TABLE I. APPLICATION OF EUROPEAN DIRECTIVE 96/29 EURATOM — EVALUATIONOF ADDED EFFECTIVE DOSE BESSINES SITE (FRANCE) YEAR 1997 — LIVING AREA — 3500h INDOORS AND 3500h OUTDOORS

STATIONS	Gamma mSv	Δ gamma mSv	Dust mSv	Δ Dust mSv	PAE Rn222* indoors mSv	PAE Rn222* outdoors mSv	Drinking water mSv	Δ Drinking water mSv	Food chain mSv	Δ Food chain mSv	Added effective dose mSv
NATURAL BACKGROUND*	0,63	0,00	<0,04	0,00	0,00	0,00	0,28	0,00	0,31	0,00	0,00
LAVAUGRASSE	0,98	0,35	<0,04	0,00	0,18	0,10	0,46	0,19	0,37	0,06	0,52
LA CHATAIGNIERE	0,63	0,00	<0,04	0,00	0,76	0,44	0,46	0,19	0,55	0,24	1,63
ABATTOIR N° 66	0,74	0,11	<0,04	0,00	0,00	0,00	0,46	0,19	0,41	0,10	0,29
BESSINES la Poste	0,63	0,00	<0,04	0,00	0,00	0,00	0,46	0,19	0,41	0,10	0,29
HOTEL DU PONT	0,67	0,04	<0,04	0,00	0,07	0,05	0,46	0,19	0,41	0,10	0,41
LA CROIX DU BREUIL	0,63	0,00	<0,04	0,00	0,00	0,00	0,46	0,19	0,41	0,10	0,29
VILLARD	0,74	0,11	<0,04	0,00	0,23	0,26	0,46	0,19	0,41	0,10	0,78

Δ = the difference between the station's value and the natural background (mSv)

* = "industrial" radon

TABLE II. APPLICATION OF EUROPEAN DIRECTIVE 96/29 EURATOM — EVALUATIONOF ADDED EFFECTIVE DOSE HERAULT SITE (FRANCE) YEAR 1997 — LIVING AREA — 3500h INDOORS AND 3500h OUTDOORS

STATIONS	Gamma mSv	Δ gamma mSv	Dust mSv	Δ Dust mSv	PAE Rn222* indoors mSv	PAE Rn222* outdoors mSv	Drinking water mSv	Δ Drinking water mSv	Food chain mSv	Δ Food chain mSv	Added effective dose mSv
NATURAL BACKGROUND*	0,31	0,00	0,08	0,00	0,00	0,00	0,01	0,00	0,08	0,00	0,00
CAPITOUL	0,25	0,00	0,08	0,00	0,00	0,00	0,01	0,00	0,16	0,08	0,08
LES HEMIES	0,63	0,32	0,08	0,00	0,00	0,00	0,01	0,00	0,16	0,08	0,40
MAS LAVAYRE	0,42	0,11	0,08	0,00	0,00	0,00	0,01	0,00	0,16	0,08	0,19
St JEAN de la BLAQUIERE Auberge	0,39	0,08	0,08	0,00	0,00	0,00	0,01	0,00	0,16	0,08	0,16
St JEAN de La BLAQUIERE	0,53	0,22	0,08	0,00	0,00	0,00	0,01	0,00	0,16	0,08	0,30
St JULIEN	0,53	0,22	0,08	0,00	0,44	0,33	0,01	0,00	0,30	0,22	1,21
St MARTIN	0,49	0,18	0,08	0,00	0,19	0,16	0,01	0,00	0,18	0,10	0,63
LA SAUVAGEONNE	0,42	0,11	0,08	0,00	0,00	0,00	0,01	0,00	0,16	0,08	0,19

Δ = the difference between the station's value and the natural background (mSv)

* = "industrial" radon