Estimation of the Individual and Collective Doses Received by Workers and the Public During the Transport of Radioactive Materials in France Between 1981 and 1990

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INTRODUCTION

The estimation of the doses received by the workers and the public has been followed up in France on a triennial basis since 1981. It is realized according to the recommendations of the ICRP, to make a verification of the quality and efficacy of the protection by means of statistical assessments of the exposures. It permits follow-up of the evolution of the exposures during the time and drawing of general trends.

This paper deals with the transport of radiopharmaceutics, irradiated fuels, wastes, and other radioactive materials including unirradiated fuels and other uranium compounds. It covers the period between 1981 and 1991.

As far as possible the evolution of the doses is related to the variation during the time of the number of transported packages and of the mass or the volume of the transported materials.

I. RADIOPHARMACEUTICS

The number of the packages transported in France is in constant progression reaching 160 000 in 1991, about 1/6 of them being technetium 99 generators.

One part of the packages is carried by the road directly to the users, to the railways stations, and to the airports, Figure 1 gives this repartition during the years 1989-1991.

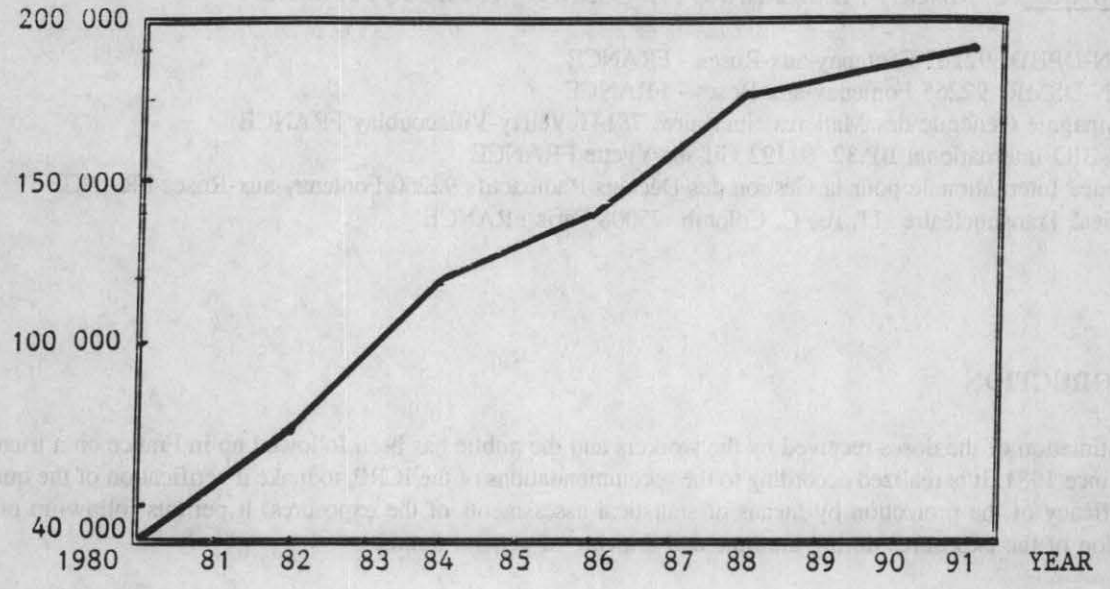
Figure 1

YEAR	MODE	RADIOACTIVE PACKAGES	RADIOACTIVE AND NO RAD. PACKAGES	TOTAL
1989	Rail/road	75 268	108 373	
	Air	61 890	74 219	
	Sea	2	2	182 592
1990	Rail/road	86 653	110 925	
	Air	68 857	75 966	
	Sea	6	6	186 897
1991	Rail/road	90 303	115 041	
	Air	69 295	76 580	
	Sea	13	62	191 683

Figure 2 indicates the evolution of the number of packages carried between 1980 and 1991.

Figure 2

RADIOPHARMACEUTICS - NUMBER OF PACKAGES PER YEAR



I-1 Doses received

The transport of radiopharmaceutics includes four distinct operations :

- packaging and loading
- transport by road to the users, railways stations or airports
- intermediate transport and storage in transit
- delivery

Transport itself is realized by a team of 8-9 persons which are category A workers. Only the first two operations have been directly evaluated in this study. The most part of the packages being transported by road, the doses received during intermediate transport (rail and plane), storage in transit and delivery have been estimated to be one-half of the doses received during the package and transport by road.

Individual and collective doses received during packaging and transport are given in figures 3 and 4 for the years 1981-1991.

Figure 3

RADIOPHARMACEUTICS PACKAGING								
YEAR	**1981**	**1983**	**1984**	**1987**	**1988**	**1989**	**1990**	**1991**
Max.dose mSv	24	19	15	11	8	8	15	10
Mean dose mSv	20	11	9	8	5.5	5	6	8
Collect Dose Man.Sv	0.14	0.1	0.08	0.06	0.05	0.05	0.06	0.07

Figure 4

RADIOPHARMACEUTICS TRANSPORT								
Year	**1981**	**1983**	**1984**	**1987**	**1988**	**1989**	**1990**	**1991**
Max.dose mSv	30	21	19	21	20	19	23	17
Mean dose mSv	13	14	13	12	11	11	10	11.5
Collect. dose Man.Sv	0.12	0.13	0.12	0.11	0.1	0.09	0.08	0.08

I.2 Comments

For the drivers the doses have continuously decreased from 1981 to 1991, in spite of the increase of the number of transported packages. The increase of the doses in year 1990 is due to the accidental exposure of a dosimeter left out by a driver in a loaded vehicle.

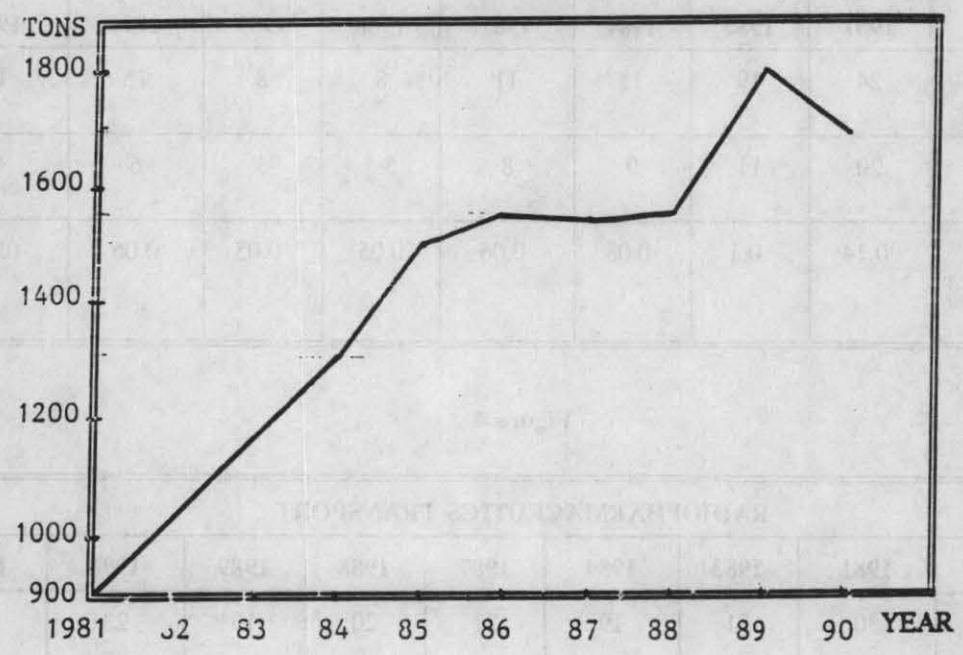
Taking into account the doses received during intermediate transport storage and delivery, the total collective dose for the workers due to the transport of radiopharmaceutics may be estimated to about 0.25 man x Sievert.

II. IRRADIATED FUELS

In France irradiated fuels are carried mainly by rail. The road is used only between some power plants and the next railway station and between the rail terminal and the La Hague reprocessing facility. Figure 5 describes the evolution of the tonnage of irradiated fuels transported between 1981 and 1991.

Figure 5

IRRADIATED FUELS- TONS/YEAR



II.1 Doses received

Figure 6 gives the evolution of the doses received between 1981 and 1991.

Figure 6

IRRADIATED FUELS								
Year	**1981**	**1983**	**1984**	**1986**	**1988**	**1989**	**1990**	**1991**
Max.dose mSv	-	4.2	5.8	1.5	4.7	-	4.7	2.6
Mean dose mSv	0.4	1.1	0.6	0.6	1	0.75	0.65	0.5
Collect. dose Man x Sv	0.006	-	0.01	0.01	0.01	0.008	0.007	0.006

II.2 Comment

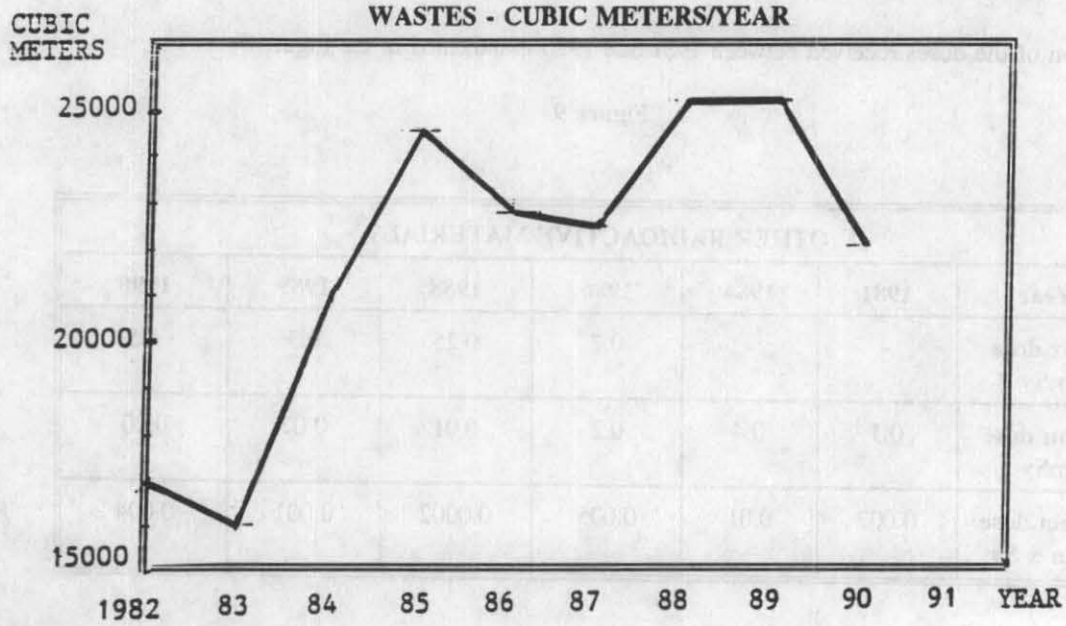
Taking into account that between 1981 and 1990 the tonnage has been multiplied by a factor of 2, one can note a relative stability of the mean, collective and maximum doses which lie well below the actual limits of dose.

III. WASTES

The transport of wastes between the various producers and the storage center of La Hague is made only partly by road and principally by rail as in this case of irradiated fuels.

Figure 7 gives the evolution of the volume of wastes transported in France between 1982 and1990. These volumes have hardly raised until 1989, because of the expansion of the nuclear energy production program. It declines in 1989-1990. This reduction results mainly from a better sorting out and a better management of the wastes by the producers.

Figure 7



III.1 Individual and collective doses

Individual and collective doses due to the transport of wastes in France are given in figure 8 for the years 1981 to 1991.

Figure 8

TRANSPORT OF WASTES								
Year	**1981**	**1984**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991***
Max.dose mSv	-	6.8	7.6	4.3	4.1	3.65	5.05	3.4
Mean dose mSv	3.3	1.8	2.8	1.7	1.8	1.08	1.07	1.09
Collect.dose Man x Sievert	0.04	0.04	0.08	0.04	0.05	0.03	0.03	0.03

* Partial

III.2 Comment

One can note that the maximum and mean doses decrease continuously between 1981 and 1990. The collective doses remain quite stable. The maximum doses remain well below the actual limits of dose. Thus the contribution of the transport of wastes to the irradiation of the workers and of the public is still very low.

IV. OTHER RADIOACTIVE MATERIALS

The tonnage of the transported materials including mainly unirradiated fuel and uranium compounds is quite stable and remains around 7 000 tons per year.

IV.1 Individual and collective doses

The evaluation of the doses received between 1981 and 1990 is indicated in the Figure 9.

Figure 9

OTHER RADIOACTIVE MATERIALS						
Year	**1981**	**1984**	**1986**	**1988**	**1989**	**1990**
Max.dose mSv	-	-	0.7	0.25	0.3	1.5
Mean dose mSv	0.1	0.4	0.2	0.01	0.07	0.20
Collect.dose man x Sv	0.002	0.01	0.005	0.0002	0.001	0.004

These doses relate to workers ensuring transport and also participating in the handling and control of the transported materials. Individual and collective doses are low and appear quite stable in time.

V. GAMMAGRAPHY SOURCES

These sources are relatively numerous in France (about 850) and about one-half are daily transported by their users from their storage site to their utilisation site. The dosimetric control of the workers is theoretically realized but, given the multiplicity and the geographic dispersion of the users, the collection of the results is very difficult. Their evaluation could not be realized for this study.

VI. COLLECTIVE DOSE FOR THE WORKERS AND THE PUBLIC

Figure 10 summarizes the evolution of the mean and collective doses received by the workers between 1981 and 1990. The collective dose for the workers lies around 0.30 man x Sievert per year.

The public residing along the communication ways (road and rail), near the sites of storage in transit, or using the planes, may also receive doses due to the transport of radioactive materials. In the previous studies one had supposed that the collective dose received by the public could be at the most one half of the collective dose received by the workers i.e. about 0.10 - 0.15 man x Sievert per year.

Figure 10

	1981		1986		1990	
	Dose		Dose		Dose	
Materials	**Mean mSv**	**Collective Man x Sievert**	**Mean mSv**	**Collective Man x Sievert**	**Mean mSv**	**Collective Man x Sievert**
R. Pharm.	12	0.44	8.5	0.30	10	0.25
Irra. fuels	0.4	0.006	0.6	0.01	0.65	0.007
Wastes	3.3	0.04	2.8	0.08	1	0.03
Others	0.1	0.002	0.4	0.009	0.24	0.004
Collective dose Man x Sievert		0.48		0.40		0.30

Conclusion

This study concerns the most important societies employing the most part of the workers involved in the transport of radioactive materials. However a small number of societies could not for various reasons take part to the study in particular those using gammagraphy sources.The study indicates that the doses received by the workers during the transport of the main radioactives materials are low and remain quite at the same level as in 1981. All are less than or in a few cases of the order of magnitude of the actual limits of dose as specified by the new recommandations of the ICRP. Further improvements in the reduction of doses could result in particular of an attentive study of the working places and the working conditions and in some cases of a better protection of the drivers. Furthermore the collective dose received by the monitored workers represents only a fraction of the total collective dose resulting of the transport considered as a "practice". The knowledge of the doses received by the public would need a systematic study of the exposures in the planes and in some places along the ways used by the conveyances of radioactive materials. These values could be profitably cross-checked by the use of an estimative model like INTERTRAN or RADTRAN.