Evolution of Radiation Doses Received by Workers and the Public During the Transportation of Radioactive Materials in France

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INTRODUCTION

This study makes an inventory of external irradiation dose equivalents and collective dose equivalents received by workers and the public during the transportation of radioactive materials in France between 1982 and 1988 (in the following, we use only the term dose).

It deals with the transport of radiopharmaceuticals, irradiated fuels, wastes and other various radioactive materials. The evolution of the doses is referred to the variation of the number of packages, the mass on the volume transported for these main categories of materials.

The transportation of radioactive materials uses various transport means : road, rail, air, and implies the intervention of various societies. Most of them have taken part in this study. Most societies involved in the transport carry out an individual dosimetry of the workers. But the decisions to carry such a dosimetry depends on the appreciation of the employer in relation with the more or less evident level of risk resulting from the transport and handling of the radioactive materials. The relatively low level of risk in current situations could incite some carriers not to carry out individual dosimetry. Thus the knowledge of individual doses essentially variables with the workers would therefore be difficult.

RADIOPHARMACEUTICALS

The number of packages manufactured in France and in sale in France and in other countries, increased from 38 200 in 1980 to 173 000 in 1988. About 1/6th is formed by Tc 99 generators. The main part of these packages is carried by road directly to the users, to the railway stations or the airports. In 1988 the distribution was as follows :

Road	61 699 packages
Rail	30 279 packages
Air	81 256 packages
TOTAL	**173 234 packages**

Figure 1 gives the number of packages annually transported between 1980 and 1988. It was multiplied by 4.5.

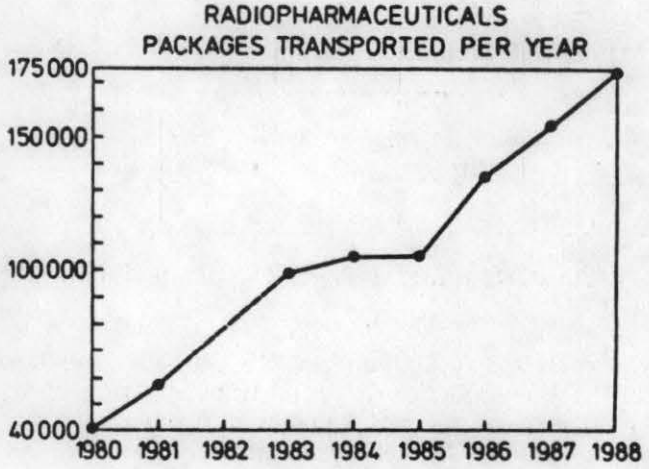

FIGURE 1

Doses received during packaging

Packaging is realized by a team of 8-10 persons. Individual and collective doses are given on Figure 2. In spite of the rise in the number of the packages, the mean annual doses decreased from 14 mSv in 1982 to 5 mSv in 1988.

FIGURE 2	JH RADIOPHARMACEUTICALS PACKAGING PAT 89			
YEAR	1981	1984	1986	1988
MEAN ANNUAL DOSE mSv	14	10	8	5
ANNUAL COLLECT DOSE Man. mSv	120	80	80	50

This reduction has been obtained by a mechanization of the packaging operations reducing human interventions to a minimum. To these doses must be added doses received by "occasionnal staff" but these supplementary individual and collective doses are very low.

Transportation by road

The transport is realized by a team of 9 drivers. The individual and collective doses (given on Figure 3) have slightly decreased between 1980 and 1988.

FIGURE 3	JH RADIOPHARMACEUTICALS TRANSPORT PAT 89			
YEAR	1981	1984	1986	1988
MEAN ANNUAL DOSE mSv	12	13	11	11
ANNUAL COLLECT DOSE Man. mSv	110	116	110	100

Doses received during the intermediate transport by rail or air or during delivery

For symmetry purposes, as in the 1986 study (Hamard, 1986), they have been supposed to be equivalent to those received during road transportation and packaging. In spite of the important number of packages transported by rail and by air we have obtained no informations on the dosimetric results corresponding to these modes of transport.

Summary of the doses received

During the year 1987, the total collective dose received during the various operations of radiopharmaceuticals transport is estimated to be about 0.37 man.Sievert.

IRRADIATED FUELS

The transportation of irradiated fuels is carried out in France mainly by rail. The road is only used between some power plants and the next railway station or between the rail terminal and the reprocessing facility. Figure 4 describes the evolution of the transported tonnage which increased from 1 300 T in 1984 to 1 550 T in 1988.

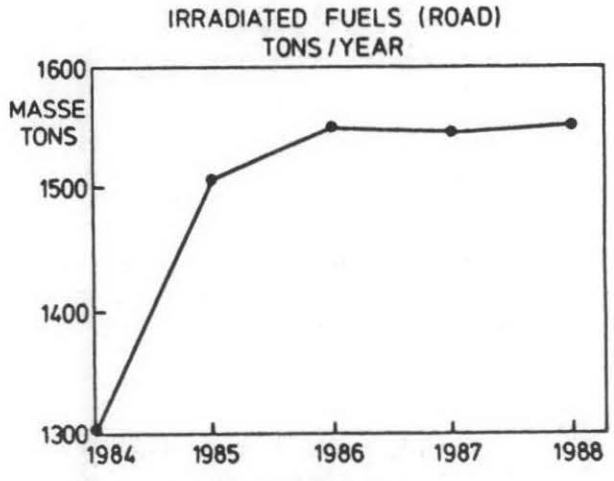

FIGURE 4

Annual and collective doses

Figure 5 gives the evolution of the mean annual individual and collective doses between 1984 and 1987. Individual doses remain unchanged. Nevertheless there is a slight increase of the collective doses due to the rise of the number of workers employed for this kind of transport.

FIGURE 5	JH IRRADIATED FUELS TRANSPORTED BY ROAD PAT 89			
YEAR	1981	1984	1986	1988
MEAN ANNUAL DOSE mSv	0,4	0,6	0,6	0,5
ANNUAL COLLECT DOSE Man. mSv	6,2	23	14	11,5

WASTES

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

Figure 6 gives the evolution of the volume of wastes transported in France between 1982 and 1988. These volumes have been roughly multiplied by 1.6 during this period raising from 17 000 to 25 000 m^3 per year.

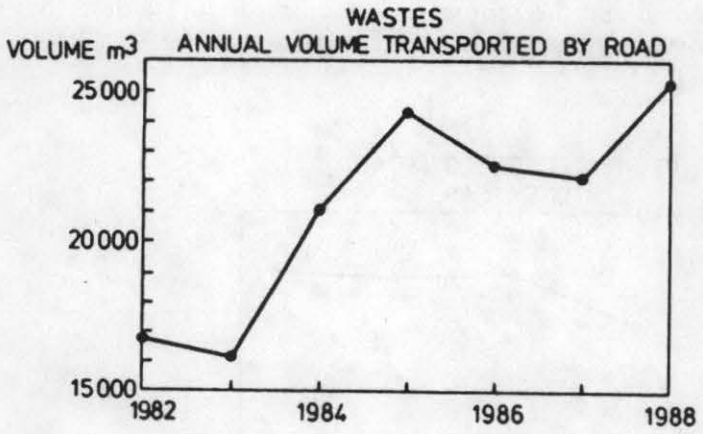

FIGURE 6

Individual and collective doses

Figure 7 indicates the evolution of the mean annual individual and collective doses between 1982-1987. The individual doses have slightly decreased from 3.3 mSv to 1.8 mSv. It is the result of a policy intending to reduce human

interventions during the transport. For example, the utilisation of "bar-code" labels allows a quicker identification of the content. Likewise the simple manipulators which required manual hoocking have been supersided by automatic manipulators. The collective doses have undergow a slight increase between 1981-1988.

FIGURE 7	JH WASTES TRANSPORTED BY ROAD PAT 89			
YEAR	1981	1984	1986	1988
MEAN ANNUAL DOSE mSv	3,3	1,8	2,8	1,8
ANNUAL COLLECT DOSE Man. mSv	39	40	83	53

OTHER RADIOACTIVE MATERIALS

This title gathers radioactive materials other than radiopharmaceuticals, common irradiated fuels, and wastes ; it includes uranium (UF_4, UF_6, UO_2), unirradiated fuels, liquid effluents, etc.

Individual and collective doses

Figure 8 gives the evolution of the mean annual individual and collective doses between 1981-1988. One can note the doubling of these doses which nevertheless remain within reasonable limits.

FIGURE 8	JH OTHER RADIOACTIVE MATERIALS PAT 89			
YEAR	1981	1984	1986	1988
MEAN ANNUAL DOSE mSv	0,1	0,4	0,4	0,26
ANNUAL COLLECT DOSE Man. mSv	2	11	9	6

TRANSPORTATION OF GAMMAGRAPHY SOURCES

In spite of the great number of societies (400) using these devices and of the transports (200 per day in France) it has not yet been possible, as in 1986, to gather valuable data relating to the doses received during the transportation of these sources.

COLLECTIVE DOSE TO THE PUBLIC

In 1984, J. BRENOT and J.P. GILLES assumed the collective dose to the public due to the transport of radiopharmaceuticals to lie between 0.01 and 0.1 man.Sievert. One can consider it reasonably to be slightly lower for the other types of radioactive materials, taking into account the mode of transport (mainly by rail) and the systematic avoidance of towns. One can then estimate that the collective dose received by the public would be about half the dose received by transport workers i.e. in the range of 0.25-0.30 man-Sievert.

SUMMARY AND CONCLUSIONS

The trend of the collective doses during the period 1981-1988 is summed up in Table 9.

FIGURE 9	SUMMARY OF THE RESULTS		
MATIERES	COLLECTIVE DOSE EQ MAN - SIEVERT		
	1981	1984	1987
RADIO-PHARM	0,440	0,416	0,370
IRRAD. FUELS	0,006	0,023	0,011
WASTES	0,040	0,040	0,053
OTHERS	0,002	0,011	0,006
TOTAL	0,488	0,490	0,440

These results show that for the main categories of packages the collective doses have decreased or only slightly increased (between 1981 and 1987). In the case of radiopharmaceuticals one must take into account that this kind of packages is subject to many manual handlings during transport and delivery. Furthermore, the doses received during packaging and delivery have been accounted for, in opposition to other categories of materials for which such information was not available. In order to estimate the progress accomplished in this case one must underline that in spite of the strong rise of the traffic (number of packages x 4.5) the individual and collective doses have been substantially lowered between 1981 and 1987. This is the result of a continuous effort of optimization and minimization of the individual doses, in which the mechanization of packaging

operations has played a major part. We have seen that a similar effort has also been made in the case of wastes and irradiated fuels for which individual doses remain at the same level as in 1981. (In this last case, the increasing number of electrical power plants has increased the number of transports and exposed workers resulting in a slight increase of the collective dose).

The main information resulting of this study is that the total collective dose equivalent including exposure of the public remains low and at the same level as the values observed in 1981 and 1986 i.e. about 0.7 man-Sievert. The radiation dose due to the transport of radioactive materials in France still represents a small fraction of the collective dose due to the complete fuel cycle. But the knowledge of the doses received should still to be improved.

REFERENCES

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