

OCCUPATIONAL EXPOSURE TO X-RADIATION IN POLAND IN THE YEARS 1966–1988

BOŻENA NOWAK and JERZY JANKOWSKI

Department of Radiation Dosimetry, The Nofer Institute of Occupational Medicine, Lodz, Poland

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Abstract. The paper presents the results of measurements of individual doses received by persons occupationally exposed to X-radiation. About 99.5% of the monitored population receives an annual dose equivalent below 0.1 of the limit i.e. below 5 mSv. Doses higher than annual limit occur only very rarely – a few cases each year.

INTRODUCTION

Measurements of individual doses received by persons occupationally exposed to X-radiation have been carried out centrally for the whole Poland by the Nofer Institute of Occupational Medicine in Lodz since 1966.

As in some other countries the measurements are performed by means of dosimetric films placed in polystyrene badges containing a set of copper and lead filters. The advantages of these dosimeters are as follows:

- wide measurement range: in the case of home-made dosimetric films “Foton” the lowest dose that may be evaluated is $2.58 \cdot 10^{-6}$ C/kg (10 mR), whereas the highest one is $7.74 \cdot 10^{-3}$ C/kg (30 R);

- dosimetric films may be used to determine not only the dose magnitude but also the energy and approximate angle of incidence of radiation;

- dosimetric films are documents; in the case of some doubts it is feasible to repeat the analysis of the density and dose evaluation. It is a great advantage because the same procedure is not possible when some other dosimeters (e.g. ionizing chambers or thermoluminescent dosimeters) are used.

The disadvantage of this method, however, is its relatively low accuracy of dose evaluation resulting, first of all, from the dependence of dosimeter indications on the energy of radiation.

Address reprint requests to B. Nowak, The Nofer Institute of Occupational Medicine, P.O. Box 199, 90-950 Lodz, Poland.

MEASUREMENT METHODOLOGY

Dose measurement consists in comparing the optical density of dosimetric film worn by the worker with the optical densities of the standard films exposed to determined doses of X-radiation of known energy. Standard and measuring films are from the same series and developed simultaneously. For each new supply of dosimetric films an evaluation of method accuracy of dose determination is made. Several films from a given series are irradiated with various doses of X-radiation emitted at various kilovoltages and additional filtration, and the doses are measured concurrently by means of a standard ionizing chamber. Next, the dose values registered on particular films are determined by routine method (1). The values obtained are compared with the actual ones — i.e. with the indications of the standard chamber — and the relative errors are determined. In the case of films recently used the relative error in dose determination does not exceed $\pm 15\%$.

MEASUREMENTS ORGANIZATION

The dosimetric films are distributed among all institutions using X-ray equipment all over Poland. The measurement period lasts two months. If a person is employed in several X-ray departments (this mainly concerns radiologists and electroradiology technicians), he/she uses a separate dosimetric film in each place of his/her employment. This allows an assessment of exposure to be made in a given work place and easy identification of the laboratory in which the dose limit has been exceeded. After termination of the two month measurement period, films are sent back to the Institute where they are subjected to photochemical treatment and the values of doses registered on particular films are determined. Next, detailed specifications of results, as well as the new sets of films for next period, are sent to particular X-ray departments.

If the registered dose in a given department exceeds the value of 0.1 of the annual limit, then the appropriate Regional Sanitary and Epidemiological Station is notified. The Station should directly control the working conditions in such a department, elucidate the reasons for excessive dose value and recommend measures to prevent such excess in the future.

In addition, this Institute provides annual lists containing the values of the annual dose equivalents received by monitored individuals to Regional Sanitary and Epidemiological Stations and Regional Occupational Health Care Centers controlling the health status of persons occupationally exposed to ionizing radiation.



MEASUREMENT RESULTS

In 1966 when the Institute in Lodz started the systematic control of individual exposure, about 11,000 persons employed in 1,900 assorted institutions were covered by regular measurements. In 1988, dosimetric measurements were carried out on 24,083 individuals employed in 2,552 departments.

In Table 1, the structure of monitored persons according to the type of institutions and professions of individuals employed there, is presented.

Health care workers constitute about 83% of the total monitored population. The most numerous occupational group are technicians — about 60% — whereas physicians constitute only 20% of the total population subjected to control.

Table 1. Structure of the population occupationally exposed to X-radiation

Type of institution	Numbers of persons in group and % of total population	Percentage of persons in a given population:					
		physicians	technicians	nurses	record keepers	auxiliary personnel	others
Total population	24 083 (100.0)	19.98	59.28	7.18	3.93	3.43	6.20
Out-patient health care	5 397 (24.4)	19.48	68.22	1.42	8.78	2.05	0.05
In-patient health care	13 195 (54.8)	27.84	51.19	12.28	3.47	4.96	0.26
Medical schools	1 366 (5.7)	0.00	98.72	0.00	0.00	0.00	1.28
Sanitary-Epidemiological Stations	162 (0.7)	0.68	30.14	0.00	0.00	0.00	69.18
X-ray unit repairshops	668 (2.8)	0.00	86.44	0.00	0.00	0.00	13.56
Research institutes	1 049 (4.4)	0.00	17.55	0.00	0.00	0.00	82.45
Industry	1 902 (7.9)	0.00	86.18	0.00	0.06	1.27	12.49
Veterinary medicine	142 (0.6)	0.00	15.12	0.00	0.00	11.63	73.25
Others	202 (0.8)	20.39	40.78	6.80	0.97	8.74	22.33



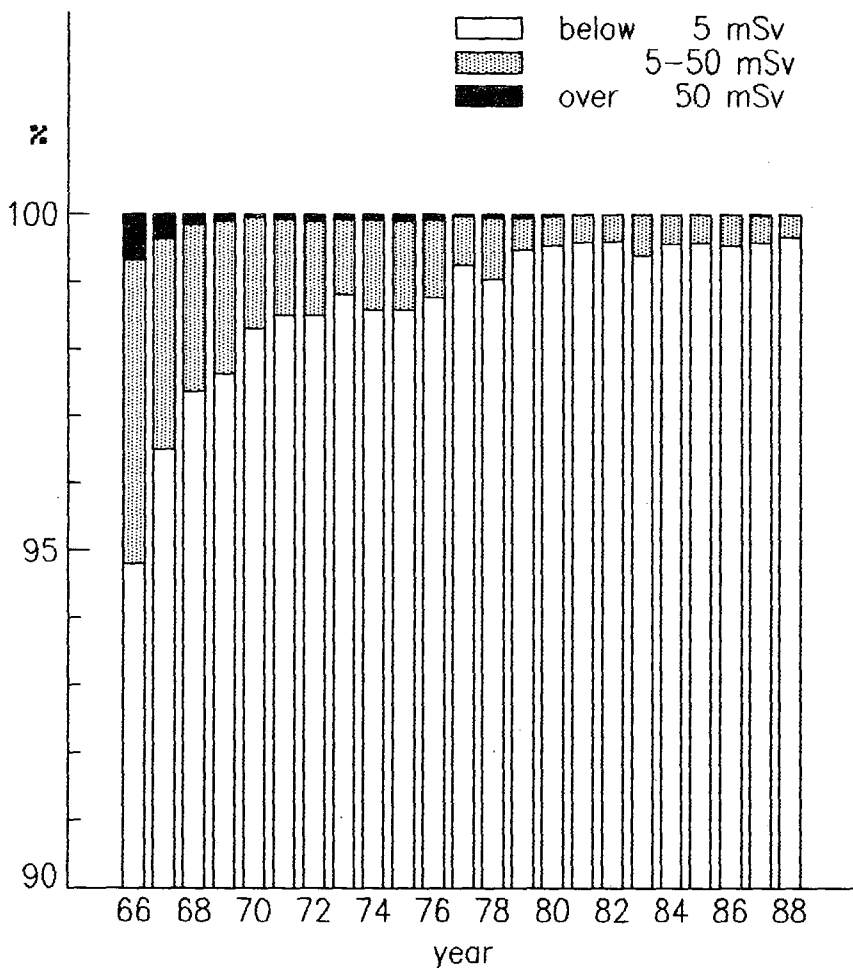


Fig. 1. Percentage of persons who received annual dose equivalents in the ranges: 0–5, 5–50 and over 50 mSv.

The results of individual dose measurements in the years 1966–1988 are presented in Fig. 1. For each year, a percentage of individuals who received the annual dose equivalents in each of the following ranges: 0–5, 5–50, over 50 mSv is given.

It is to be noted that in 1966 the group of those who received annual dose equivalents below 0.1 of limit value i.e. 5 mSv (2), constituted about 95% of the total monitored population. Since 1977 the group of persons receiving annual dose equivalents below 5 mSv has been on more or less the same level, reaching about 99.5%. It is note-worthy that about 90% of controlled persons receive systematically – in each measurement period – a dose equivalent below the sensitivity of the method i.e. 0.1 mSv.



In 1966 an annual dose equivalent in the range of 5–50 mSv was received by a group of persons constituting about 4.5% of the monitored population. In subsequent years a gradual decrease of this percentage has been observed. In the last decade, doses in that range were received by only 0.5% of the total population.

Annual dose equivalents higher than 50 mSv have occurred sporadically – a few cases per year (Fig. 2).

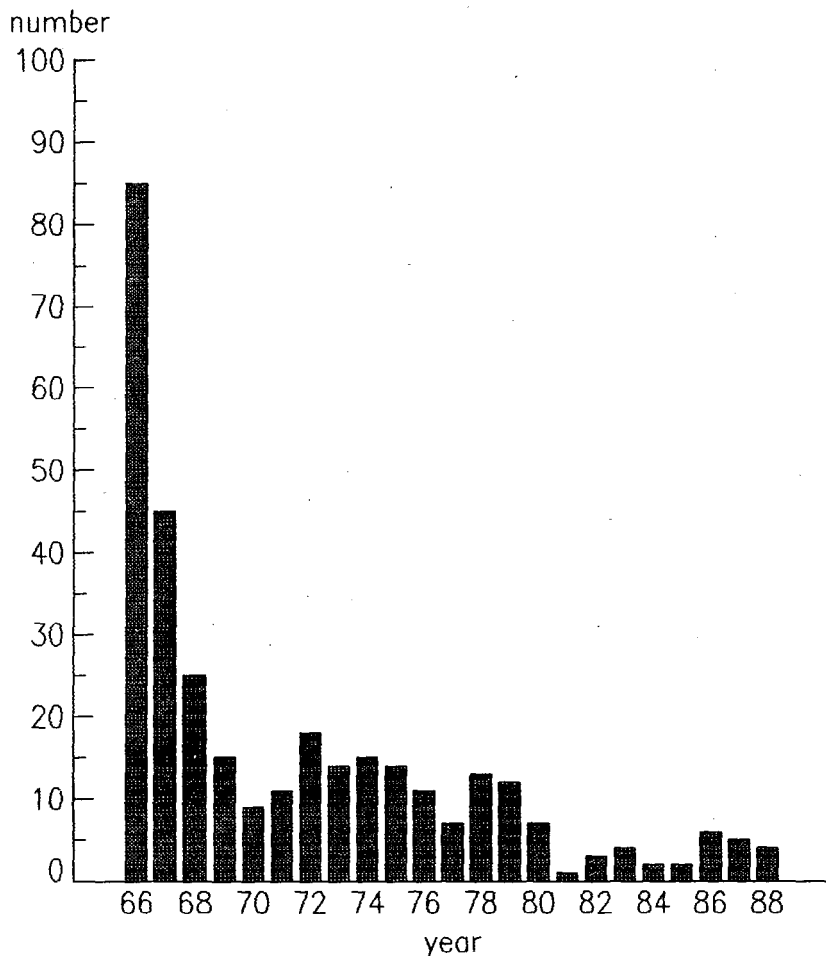


Fig. 2. Number of persons who received annual dose equivalents of over 50 mSv.

To illustrate the current individual exposure to X-radiation, the results of measurements made in 1988 are presented in Table 2. The Table comprises the percentage of persons (from each group of X-ray workers) receiving doses from determined ranges.

Table 2. Distribution of annual dose equivalent in X-radiation workers in 1988

Type of institution	Percentage of populations who received annual dose equivalent in the range of: (mSv)						
	0-1	1-2	2-5	5-10	10-20	20-50	> 50
Total population	98.10	0.85	0.72	0.18	0.08	0.05	0.02
Out-patient health care	98.83	0.57	0.45	0.11	0.02	0.02	0.00
In-patient health care	97.29	1.23	1.04	0.25	0.11	0.06	0.02
—hospitals	97.30	1.25	1.06	0.26	0.06	0.04	0.03
—operating theatres	98.34	0.81	0.54	0.19	0.12	0.00	0.00
—operational radiology	91.84	2.85	3.03	0.38	1.14	0.76	0.00
Medical schools	100.00	0.00	0.00	0.00	0.00	0.00	0.00
Sanitary-Epidemiological Stations	100.00	0.00	0.00	0.00	0.00	0.00	0.00
X-ray unit repairshops	97.90	0.30	0.90	0.15	0.45	0.30	0.00
Research institutes	99.81	0.00	0.19	0.00	0.00	0.00	0.00
Industry	99.00	0.53	0.21	0.16	0.05	0.00	0.05
Veterinary medicine	99.30	0.70	0.00	0.00	0.00	0.00	0.00
Others	100.00	0.00	0.00	0.00	0.00	0.00	0.00

In Table 3, a detailed structure of persons who received annual dose equivalents higher than 5 mSv is shown. In 1988, 79 cases were recorded. As per the results from presented data values of over 0.1 of annual limit are relatively more frequently recorded in the group of in-patient health care workers (59 cases). In the majority of cases this concerns the physicians (35 cases) who stay next to X-ray tube during the emission of radiation. These are mainly persons participating in vascular and other complex X-ray examinations involving emission of radiation for a long time. These persons receive increased doses in most measurement periods.

Annual dose equivalents higher than 5 mSv are recorded in the group of electroradiology technicians who perform X-ray examinations in patients'



Table 3. Number of individuals who received doses higher than 0.1 of annual dose equivalent in particular groups

Type of institution	Number of individuals who received annual dose equivalent higher then 5 mSv						
	total	physicians	technicians	nurses	record keepers	auxiliary personnel	others
Total	79	42	27	6	—	3	1
Out-patient health care	9	7	2	—	—	—	—
In-patient health care	59	35	15	6	—	3	—
X-ray unit repairshops	6	—	6	—	—	—	—
Industry	5	—	4	—	—	—	1

rooms using mobile X-ray units. Generally, however, these are single incidental cases unconnected with routine work performed in fully shielded rooms.

The excessive exposure by X-ray unit repair workers is also associated with routine work they perform in the vicinity of radiation sources.

Cases where the value of 0.1 of the limit in the remaining group of workers are mainly connected with improper organization of work.

The presented analysis indicates that a significant decrease in occupational exposure to X-radiation has been achieved recently. It is close to the level of exposure reported in some other countries (3).

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