MONITORING AND CONTROL OF OCCUPATIONAL RADIATION EXPOSURE IN SWITZERLAND

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Abstract
Occupational exposure is the most prominent example for the prolonged exposure to low level ionizing radiation characterized by low doses and dose rates. In this paper the occupational exposure in Switzerland is presented and the regulatory control of this exposure in the framework of the new radiation protection regulations is discussed.

1. OCCUPATIONAL EXPOSURE IN SWITZERLAND

According to the statistics for 1996 [1] there were about 62000 radiation workers in Switzerland. Dose distributions in the different employment categories are shown in Table I. Almost the whole collective dose comes from the four distinguished fields: nuclear power plants, medicine, industry and research. These main fields have very different exposure characteristics and therefore different possibilities for exposure optimization.

More than half (53%) of the total collective dose is received by workers of the five Swiss nuclear power plants. The dose is divided between employees (30% of the workers, 37% of the collective dose) and contract workers. There are only about 1% women. The major part of the exposure comes from external photon radiation. Exposure from neutron radiation and internal contamination are negligible.

About half of all radiation workers are employed in medicine, about an equal number in hospitals and in the private medical practices. In 1996 they accumulated 13% of the total collective dose, 77% of it in hospitals. This is the only field with predominantly female radiation workers (64%). They received 48% of the collective dose in medicine.

19 % of the total collective dose is received by workers of universities and research institutes, mainly of the two research centers: the Paul Scherrer Institute and the European Organization for Nuclear Research. The exposure in these institutes is characterized by very different and inhomogeneous radiation fields mainly from accelerators. About 22% of the accumulated dose comes from neutron radiation. Radiation workers are both employees and temporary researchers, 17% are women.

Industry contributes 12% to the total collective dose. About 75% of it comes from tritium incorporation in the luminizing industry, received almost exclusively by women.

In the category „others", dentists, veterinary practices and public services are put together. This group is characterized by a relatively large number of radiation workers, but very small radiation doses (3% contribution to the total collective dose).

TABLE I. EFFECTIVE DOSES FOR EXTERNAL AND INTERNAL RADIATION 1996: NUMBER OF PERSONS AND COLLECTIVE DOSE [a]

Dose bracket [b] (mSv)	Nuclear power plants	Universities Research	Medicine	Industry Trade [c]	Others	Total
0 - 1	3020	9520	30034	3015	13917	59506
1 - 2	493	191	105	70	19	878
2 - 3	312	83	33	64	4	496
3- 4	206	46	22	45	1	320
4 - 5	116	25	13	25	1	180
5 - 6	102	14	14	21		151
6 - 7	60	10	4	8	1	83
7 - 8	45	2	9	10		66
8 - 9	26	2	1	10	2	41
9 - 10	17	1	2	4		24
10 - 11	14	2		5		21
11 - 12	7		1	5		13
12 -13	3		1	1		5
13 - 14	2		2			4
14 - 15	1			1		2
15 - 16	3					3
16 - 17				1		1
17 - 18				1		1
18 - 19				1		1
19 - 20						
20 - 50				1		1
> 50						
Total	4427	9896	30241	3288	13945	61797
Collective dose [Person-Sv]	5.43	1.89	1.32	1.22	0.29	10.15
Rad. workers with Dose = 0	1402	6824	27120	2745	12853	50944
Number of women	62	1648	19310	970	9759	31749
Women collective dose [Person-Sv]	0.01	0.10	0.64	0.92	0.16	1.83

[a] 54604 persons were monitored for external radiation only, 787 only for internal radiation and 6406 for both

[b] Doses which lie exactly on bracket boundaries are allocated to the lower brackets.

[c] In the category „Industry" the number of radiation workers with a dose=0 and the data for women were estimated for the 787 persons being monitored only for incorporation (as these data are not available from the Registry).

2. REGULATORY CONTROL OF THE OCCUPATIONAL EXPOSURE

The regulatory control of the occupational exposure is defined in the Radiation Protection Ordinance of 22 June 1994, in effect since 1. January 1995. The Ordinance is based on the ICRP-Publication 60 [2]. With the Ordinance the new dose quantities Hp(10) and Hp(0.07) are introduced

together with the new dose limits: 20 mSv per year, whereby the dose may amount to 50 mSv per year with the approval of the regulation authority, provided that the cumulative dose of the past five years remains below 100 mSv. A limit of 5 mSv per year is to be complied with for adolescents in the age group 16-18 years. For women exposed to radiation in the course of their work, the dose equivalent at the abdomen is limited to 2 mSv from knowledge of a pregnancy until its end. The allowed effective dose as a consequence of incorporation is 1 mSv for the same time interval. The occupational lifetime dose is no longer subject to a limit. The newly introduced concept of effective dose now permits the addition of the doses due to external and internal irradiation.

The monitoring of external exposure for radiation workers is performed by 10 approved dosimetry services, mainly using thermoluminescent dosimeters. Only one service uses film dosimeters. Some dosimetry services also provide individual monitoring for internal exposure, otherwise this is done locally by the companies which use unsealed sources.

Three national authorities share the supervision in the field of radiation protection. The Nuclear Safety Inspectorate provides the supervision for the radiation workers in the nuclear installations, the National Accidental Insurance Organization oversees the radiation workers in industry and the Federal Office of Public Health (FOPH) is responsible for all other radiation workers, mainly in the fields of medicine and research.

Since 1990 the FOPH operates the National Dose Registry [3]. It contains personal, employment and dosimetric data for all radiation workers in the country. The data are transferred monthly from the dosimetry services to the Registry. The external exposure part of the above mentioned statistics is done using the data in the Registry. Incorporation data are not yet included in the Registry. For these statistics the data from the dosimetry services were used.

In addition to the dose limits an intervention level of 2 mSv per month has been introduced in the supervision field of the FOPH. Each case exceeding this level has been examined and documented. An analysis of these cases in the last 15 years is underway.

3. DISCUSSION

The occupational radiation doses in Switzerland are generally very low. The annual average dose ranges from 1.23 mSv for workers in the nuclear power installations to 0.02 mSv for category „others". The majority of radiation workers are monitored but not really exposed. In 1996 only about 18% of all radiation workers have had a measurable dose with annual mean values of: 1.8 mSv for nuclear power plants, 0.62 mSv for universities and research, 0.42 mSv for medicine, 2.15 mSv for industry and 0.27 mSv for „others".

With the introduction of the new ordinance and the new dose limits, the occupational exposure has not changed drastically. The collective dose and the average doses remained almost the same. One change in the dose distribution can nevertheless be noticed: the higher doses are pushed towards the „middle region" (about 10 mSv), probably because one is afraid to exceed the limit.

A second change can be noticed for the cases exceeding the dose limits. In the previous years they appeared mainly as isolated events, where an annual dose has been made by one single monthly dose. Now it may occur that during a normal operation with an exposure of about 2 mSv per month, the annual dose limit can be exceeded. By investigating cases above 2 mSv per month several such potential cases could be detected before they exceeded the limit. This occured mainly in the field of interventional radiology and angiography. In some cases the exposure could have been easily reduced, but in some others it was not possible. In these cases a 50 mSv annual dose limit has been approved considering the justification principle and the 5-years dose limit.

One specific problem is how to apply the dose limits to pregnant women. So far the employer has to inform female radiation workers of the danger from radiation and the dose limits during the pregnancy. In 1996 the first case exceeding this limit appeared. A woman in the luminous painting industry accumulated a dose of 5.2 mSv during pregnancy (where the limit is 1 mSv).

Luminous painting industry is the field where the women accumulate the highest occupational doses. The appropriate supervision authority put a big effort into optimizing the exposure in this field. There are a number of technical possibilities to reduce tritium incorporation, but their financing is almost unbearable for the small luminous painting companies.

The main reduction of the total collective dose (about 30%) has been achieved in 1990 due to optimizations in the field of nuclear power plants [4]. It seems that further dose reduction in this field is not very easy.

Another field with a potential for improvement of radiation protection and for exposure optimization is interventional radiology and angiography. This is a relatively new, strong developing area, with high radiation exposures because of long exposure times and small distances from the radiation sources. In addition the measured doses are underestimated because dosimeters are carried underneath protective aprons. In contrast to the classical, well established applications in medical diagnosis in this field the corresponding personnel is less educated in radiation protection and is often even not declared as occupationaly exposed. Therefore there is great need for better monitoring of the individual exposure and for better radiation protection education.

4. CONCLUSION

The introduction of the new lower dose limits for occupational radiation exposure posed no problem in Switzerland thanks to the already existing high level of the radiation protection in the country. One bigger effort to reduce the doses in the field of nuclear power plants has been done in 1990 resulting in a dose reduction of about 30% of the total collective dose. At the moment the biggest potential for further dose reduction lies in the field of interventional radiology and angiography. We believe that this can be achieved through better education of the radiation workers in this field. This would have two advantages: an occupational dose reduction on one side and lower doses for the patients due to the better consciousness of radiation exposure on other side.

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