EXPERIENCES WITH USING A CONCEPT OF ORGAN-DOSE COMBINATION AS A BASIS FOR PRACTICAL MEASURES IN RADIATION PROTECTION

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In our institute the routine individual monitoring consists mainly of measurements of the whole body- and skin doses. In some case, measurements of finger doses and internal contamination are also carried out. For a long time, only the whole body doses were presented as the exposures of the workers and used for statistical purposes. The other values were presented additionally without any correlation among them.

For the last three years our Department of Isotope Production was in steady expansion. Accordingly, incorporations got more frequent, and hand doses got higher and higher every year. This is the reason why whole body doses alone lost their significance as a measure of radiation risks at different working places.

We tried to find a concept which may enable us to determine the total radiation risk of a working place and thus may serve as a basis for practical counter-measures. Since two years, we have used a concept which is a combination of our national law and the new tendencies of ICRP.

The concept of organ dose combination

We usually distinguish 4 kinds of exposures:

1. Whole body dose (external)
2. Skin dose
3. Hand dose
4. Incorporation

The values 1, 2 and 3 are measured by suitable dosimeters. As long as the values are below the limits, we interpret the dosimeter reading as a real organ dose.

- The "whole body dose" is measured with a normal TLD-700 chips behind a material of 300 mg/cm^2 tissue equivalent.
- The "skin dose" is defined as the difference between a dose measured with a thin (0,015") TLD-700 chips behind a material of about 20 mg/cm^2 and the total body dose described above.
- The "hand dose" is measured with a normal TLD-700 chips behind a material of about 20 mg/cm^2 (as the fingerdosimeter is not worn during all the time when the personal dosimeter is worn, we don't subtract the total body dose from it).

As long as an internal contamination doesn't exeed the limit given by the law we use for every person the metabolism of Reference Man, i.e. the ratio between intake and dose commitment is constant for every person. For an internal contamination we don't calculate organdoses. We try to determine the intake using the metabolism of Reference Man. Then the limit for internal contamination is the maximum permissible intake.

- The highest levels of internal contamination which occur in the Department of Isotope Production result from I-125 and I-131. The uptake is measured with a thyroid monitor. For calculating the intake from a measured uptake we use the factor f_a from ICRP 2.

To judge the risk of an exposure it is important to know the value of the exposure relative to the limit given by the law. For this we introduced a new value, called "Belastungsindex BI" (exposure index) in our institute. BI is defined as the ratio between registered dose or intake and the corresponding annual limit :

$$BI_{\text{whole body}} = \frac{\text{whole body dose (rem)}}{5 \text{ rem}}$$

$$BI_{\text{skin}} = \frac{\text{skin dose (rem)}}{30 \text{ rem}}$$

$$BI_{\text{hand}} = \frac{\text{hand dose (rem)}}{75 \text{ rem}}$$

$$BI_{\text{incorporation}} = \frac{\text{intake}}{\text{maximum permissible annual intake}}$$

Although our law is based on the concpet of critical organ, and thus allows different organs to approach the dose limit at the same time, we introduced a stronger limitation in our concept. We define

$$BI_{\text{total}} = \Sigma \, BI_j$$

where j denotes one of the four kinds of exposures. The law prescribes that the annual BI_j be kept below 1. We attempt to do better and try to keep BI_{total} below 1 within a year and below 0,5 within a quarter of a year. The idea is to accept the same level of risk from all types of external and internal exposures or their combinations. The total risk for a worker, who receives whole body, hand and internal exposures should be kept below the same risk level as for another who only receives whole body exposures. Of course this goal can only be achieved when ICRP has corrected the relations between whole body and organ dose limits. However, this will not influence the prinicples of our method.

Practical use of the concept (an example)

All the registered exposures of each worker are put together in one dose register.

Personendosen 1975, Abteilung: IP

Nr	Name	BI_{total}	Ganzkörperdosis		Hautdosis		Handdosis		Inkorporation
			mrem	BI_G	mrem	BI_H	mrem	BI_E	Nuklid: BI_I
060		0,06	280	0,06	60	< 0,01			
702		0,12	495	0,10	--				I-125 : 0,02
724		0,01	50	0,01	--				
375		0,08	255	0,05	65	< 0,01	115	< 0,01	I-125 : 0,03
058		0,01	50	0,01	--				
252		0,47	1'495	0,30	215	< 0,01	12'870	0,17	
410		0,01	50	0,01	--				
159		0,01	50	0,01	--				
065		1,02	2'150	0,43	1'300	0,04	36'470	0,49	I-131 : 0,04 I-125 : 0,02

Fig.1: Part of the dose register 1975 of the Dept.of Isotope Production

For a general view we use a histogramm of BI_{total}.

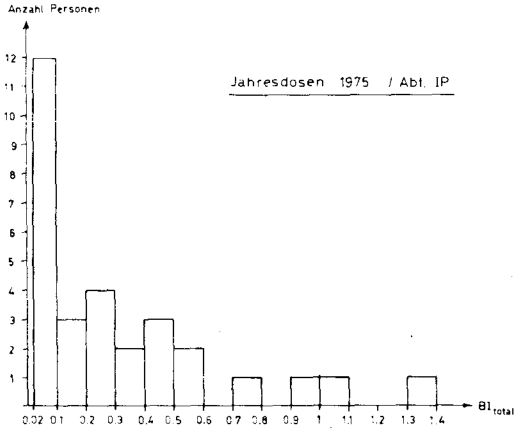

Fig.2: Histogramm of BI_{total} (Department of Isotope Production 1975)

The relative importance of the 4 kinds of exposures is presented in the following diagramm.

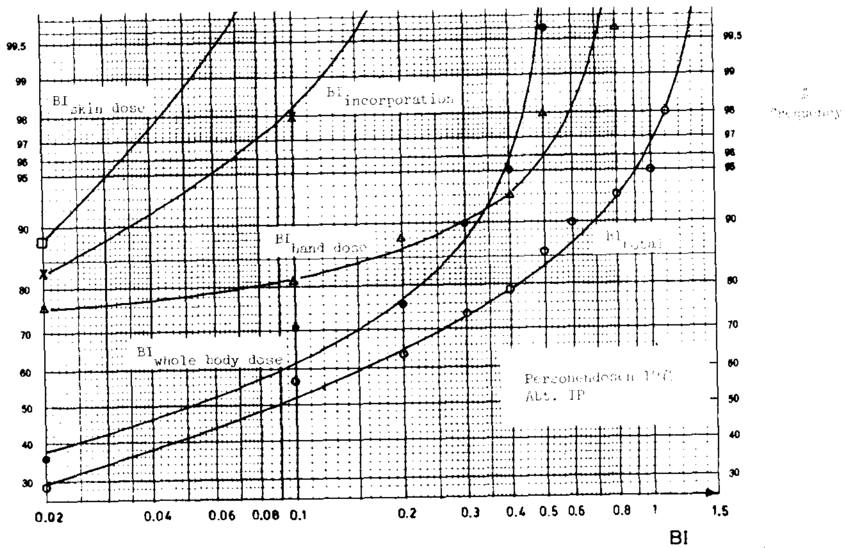

Fig.3: Relative importance of BI_j (Department of Isotope Production 1975)

Since there are only 41 workers in the Department of Isotope Production the statistic is very poor and it is not surprising that BI shows no log-normal distribution. The collective dose for a single exposure is calculated by adding the proper BI. For the presentation of these values we use the common unit "manrem", i.e. we multiply BI by 5 rem. Thus, for the Department of Isotope Production we got for 1975 :

whole body dose	23 manrem
skin dose	2 manrem
hand dose	14 manrem
incorporation	3 manrem

Discussion of the presented example

Fig. 3 and the distribution of the collective dose show that the main problems of the Department of Isotope Production are due to the whole body dose and the hand dose. Fig.3 shows that there are few workers with high hand doses and that most workers got significant whole body doses. There are neither high skin doses nor important incorporations and only few workers received registered exposures of these two kinds.

We can see from Fig.2 that for two workers the BI_{total} lies above 1. Now our aim is to keep all BI_{total} below 1. From fig.3 we learn that the best way to reach that goal is to reduce the high hand doses. When we check the distribution of the different kinds of exposures of these two workers in the dose register, we find that $BI_{hand\ dose}$ has really the highest value among all the BI_j (fig.1 shows the values for one of these two workers only).

However, for a general reduction of the exposure in the Department of Isotope Production the best way is to reduce the whole body dose.

A further reduction of internal contamination or skin dose will not result in a significant change of the total exposure, even if we do it with every effort.

Our experience with the concept shows that it is a simple and useful method to determine effective counter-measures for the practical radiation protection.

References

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