FROM BODY BURDEN TO EFFECTIVE DOSE EQUIVALENT

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In §104 of ICRP-26 the concept of "effective dose equivalent" in introduced. It is the sum of organ or tissue dose equivalents H_T weighted with appropiate relative risk factors w_T: $H_E = \Sigma_T w_T H_T$. This concept enables a direct comparison with uniform whole body irradiation as far as risk is concerned. The effective dose equivalent is a powerful tool in the assessment of internal contamination of humans with radioactive material.

In case of an internal contamination with radionuclides, that emit penetrating radiation , the whole body counter is usually used to determine the magnitude of the contamination. The problem is to relate the value of the measured body burden to the subsequent effective dose equivalent.

Two extreme cases may be considered at this point: single and continuous intake. For single intake the ICRP gives a complete model for the translocation of material in the human body. This model is based on a linear chain of compartments. A system of coupled differential eqations describes the mathematics. The solution in terms of organ or tissue burden q_i as a function of time after intake of unit activity is given by

$$q_i(t) = \left(\prod_{k=1}^{i-1} \lambda_{k,k+1} \right) \sum_{k=1}^{i} \left[\left(\prod_{\substack{p=1 \\ p \neq k}}^{i} (\lambda_p - \lambda_k)^{-1} \right) \exp(-\lambda_k t) \right] . \qquad (1)$$

Here $\lambda_{k,k+1}$ is the rate of transfer from compartment k to k+1 and λ_k is the rate of loss from compartment k, including radioactive decay. The sum of organ and tissue burdens gives the whole body burden. In a computer programme (BODYBUR) the expression (1) is evaluated for 18 points in time after a single intake. The result may be used to estimate the intake from a measured body burden.

For continuous intake the values of U_S as given in the ICRP-30 supplements are used. These are expressed in Bq.s per Bq intake. It can be shown that they may also be considered as factors expressing Bq(organ burden) per Bq/s intake rate. For short lived nuclides the values arrived at following this procedure will represent the equilibrium body burden as the result of a continuous intake during a sufficiently long period of time. For long lived nuclides a continuous intake during 50 years is assumed, which yields the final body burden.

Finally, the conversion factors giving the effective committed dose equivalent per unit intake, as derived from ICRP-data, are presented. Analogously the conversion factors relating the effective dose-equivalent rate to a steady body burden are given.

The information described above has been tabulated for 400 nuclides, with a physical halflife exceeding 12 hours. An example of the output of the programme is given on the next page.

A limited number of copies of the final report will be available to interested persons at the conference.

CO-60 HALFLIFE= 1.924E+03 DAYS
AMAD= 1.0 MICROMETER
TTC= .50 DAYS

LIVER	F2= .050	A	T(DAYS)
		.600	6.000
		.200	60.000
		.200	800.000
REST	F2= .450	A	T(DAYS)
		.600	6.000
		.200	60.000
		.200	800.000

COMPOUND	INGESTION	INHALATION CLASS D	W	Y
ORG+(INORG WITH CARRIER)	F1= 3.E-1			
(HYDR)OXIDE,INORG TRACER	F1= 5.E-2			
(HYDR)OXIDE,HALIDE,NITRATE	F1= 5.E-2			5.E-2
OTHER COMPOUNDS	F1= 5.E-2		5.E-2	

BODY BURDEN AFTER SINGLE INTAKE(FRACTION OF INTAKE)

TIME (DAYS)	INGESTION F1= 5.E-2	INGESTION F1= 3.E-1	INHALATION CLASS W	Y
.25	9.86E-01	9.69E-01	6.19E-01	6.29E-01
.50	9.23E-01	8.86E-01	6.06E-01	6.22E-01
1.00	7.11E-01	6.80E-01	5.60E-01	5.76E-01
2.00	3.35E-01	3.69E-01	4.22E-01	4.22E-01
3.00	1.46E-01	2.20E-01	3.09E-01	2.97E-01
5.00	3.68E-02	1.27E-01	2.08E-01	1.91E-01
7.00	1.95E-02	1.04E-01	1.79E-01	1.66E-01
14.00	1.25E-02	7.49E-02	1.53E-01	1.55E-01
30.00	8.38E-03	5.32E-02	1.23E-01	1.49E-01
60.00	7.14E-03	4.28E-02	8.79E-02	1.42E-01
90.00	6.21E-03	3.73E-02	6.40E-02	1.36E-01
180.00	4.60E-03	2.76E-02	2.83E-02	1.20E-01
365.00	3.26E-03	1.96E-02	1.12E-02	9.37E-02
730.00	2.04E-03	1.23E-02	6.14E-03	5.85E-02
1050.00	1.38E-03	8.28E-03	4.14E-03	3.94E-02
1625.00	5.33E-04	3.20E-03	1.60E-03	1.62E-02
3650.00	5.69E-05	3.41E-04	1.70E-04	2.86E-03
18250.00	9.48E-13	5.69E-12	2.84E-12	5.23E-06

EFF.COMM.DOSE EQUIV.(SV) PER BQ INTAKE

INGESTION F1= 5.E-2	INGESTION F1= 3.E-1	INHALATION CLASS W	Y
1.70E-09	7.00E-09	8.00E-09	4.10E-08

CONTINUOUS INTAKE

FINAL OR EQUILIBRIUM BODY BURDEN
(BQ BODY BURDEN PER BQ/DAY INTAKE)

6.20E+00	2.90E+01	2.50E+01	1.20E+02

EFF. DOSE-EQUIV. RATE CONVERSION FACTOR
(SV/Y PER BQ BODY BURDEN)

1.00E-07	8.81E-08	1.17E-07	1.25E-07

Fig.1. Body burden programme output for ^{60}Co