SPECIFIC ABSORBED FRACTIONS FOR PHOTONS EMITTED IN THE WALLS OF THE GI TRACT

S. F. Deus, V. Provenzano and W. S. Snyder

PUBLICAÇÃO IEA 515 IEA - Pub - 515	JULHO/1978

CONSELHO DELIBERATIVO

MEMBROS

Klaus Reinach – Presidente
Roberto D'Utra Vaz
Helcio Modesto da Costa
Ivano Humbert Marchesi
Admar Cervellini

PARTICIPANTES

Regina Elisabete Azevedo Beretta
Flávio Gori

SUPERINTENDENTE

Rômulo Ribeiro Pieroni

PUBLICAÇÃO IEA 515
IEA - Pub - 515

JULHO/1978

SPECIFIC ABSORBED FRACTIONS FOR PHOTONS EMITTED IN THE WALLS OF THE GI TRACT

C eus, V. Provenzano and W. S. Snyder

CENTR DE PROTEÇÃO RADIOLÓGICA E DOSIMETRIA
CPRD - AMD 038

INSTITUTO DE ENERGIA ATÔMICA
SÃO PAULO – BRASIL

Série PUBLICAÇÃO IEA

Nota: A redação, ortografia e conceitos são de responsabilidade dos autores

SPECIFIC ABSORBED FRACTIONS FOR PHOTONS EMITTED IN THE WALLS OF THE GI TRACT[1]

S. F. Deus[2], V. Provenzano[3] and W. S. Snyder[4]

ABSTRACT

Although the sections of the gastrointestinal tract (GIT) are represented as source organs in MIRD Pamphlet No. 5, the wall and contents were not separated in the model. Thus, the absorbed fractions given in that publication are perhaps more representative of the contents than of the wall. A new model is given in ORNL-5000 where the contents and the wall defined separately but only absorbed fractions (or specific absorbed fractions) are given for the source in the contents. In this paper, we give specific absorbed fractions for the source uniformly distributed in the wall of each of the three sections of the tract, namely, stomach, upper large intestine and lower large intestine. The same energies are used for the sources as in the other publications and data are given for all target organs included previously. Each computer run uses a sample of 60,000 photons and all calculations were done at the IEA at São Paulo, Brazil. When the statistics of the estimate are poor, a value obtained by use of Berger's build-up factor is substituted. Thus, a complete table of values is obtained. Activity in the walls of the tract has been reported for gallium and a check on the dose values reported by Cloutier et al. (MIRD 73) reveals that the comulated activity (μCi-days) in the contents overwhelms those from the tract and the total dose values are not greatly affected. However, differences of a factor of 2 or 3 are present when considering the contribution from activity in the walls alone

1 – INTRODUCTION

The PHANTON used to estimate absorbed fractions of photon energy in MIRD Pamphlet No. 5 (Sn69) has been improved by defining a gastrointestinal tract (GIT) where the contents and walls of the tract are separated. This makes it possible to estimate dose to the walls of the GIT from a photon emitter passing through the contents. For a fairly recent description of the modified phantom and for specific absorbed fractions (SAF = absorbed fraction per gram of the target organ) of the various organs, see ORNL-5000 (Sn74) or the tables of SAFs in the Report on Reference Man (Sn75). Until now, however, there have been no SAFs for a photon source in the walls of the GIT, and it is the purpose of this paper to supply these.

Examples are known of the need for an SAF ($X \leftarrow Y$) where Y is a section of the GIT and X is some other organ of the body. For instance, in treatments by Ga, activity has been found in the wall of the GIT and was even estimated to give a larger dose to the wall than that received by other organs, although the dosimetry was not precise (MIRD73). Similarly, it is well known that iodine and technicium injected into the body will be present in the gastric mucosa (Sm65; Mc64; Ha62). Undoubtedly, one reason for the relative paucity of data has been the makeshift character of the dosimetry generally used when activity was recognized in the walls of the GIT.

(1) Research sponsored by the U. S. Energy Research and Development Administration under contract with Union Carbide Corporation and by the Instituto de Energia Atomica, Sao Paulo, Brazil.
(2) Employee, Instituto de Energia Atomica, Sao Paulo, Brazil. Presently assigned as a research associate, Health Physics Division, ORNL.
(3) Formerly with the Instituto de Energia Atomica, Sao Paulo, Brazil.
(4) Consultant.
APROVADO PARA PUBLICAÇÃO EM JUNHO/1978.

2 – THE MODEL FOR THE GIT

The phantom used is a revision of that presented in MIRD Pamphlet No. 5 (Sn69) and represents an individual of about 70 kg mass in the erect position. Among the changes are the separation of the legs with an improved position for the gonads, the rounding of the top of the head, the addition of clavicles and scapulae, the separation of red marrow and yellow marrow, and the definitions of the walls of the bladder and the GIT. For a detailed description, the reader is referred to ORNL-5000 (Sn74) or to Snyder et al. (Sn76) to be published. The data on the ticknesses of the walls of the tract are given in Table I and have been selected on the basis of the few values given in the Report on Reference Man (Sn75) as well as in reasonable agreement with data on the length of the section and the mass. While a value of tickness is given in Table I for the small intestine (SI), it is not used in computing the SAF for photons. This is because the small intestine does not have a fixed configuration and, except for the two ends which are relatively fixed, is free to move. This means that dose from photons is averaged over the wall and the contents due to this movement, and thus a value based on some supposed configuration could be misleading. The SAF (SIW ← SIW) as well as the SAF (SIW ← SI contents) are both taken as equal to the SAF (SIW plus SI contents ← SIW plus SI contents). This applies only to photon irradiation in the SI, but for electrons the thickness of the wall should be taken into account.

Table I

Masses of Sections of the GIT and Contents with Estimates of Average Wall Thicknesses

	Mass of wall (g)	Mass of contents (g)	Average thickness of wall (mm)
Stomach	150	250	6
SI	640	400	3.5
ULI			
Ascending colon	90	95	7.1
Transverse colon	119	125	5.3
LLI			
Descending colon	90	100	3 – 7.9
Sigmoid colon	70	35	6.6

3 – THE MONTE CARLO METHOD

The estimation of SAF for photons emitted in the walls of the GIT follows the method described in MIRD Pamphlet No. 5 (Sn69) or in ORNL-5000 (Sn74). The source is assumed to be distributed uniformly in the wall of the section and the starting point of a photon history is therefore chosen randomly in the wall. As the calculation proceeds, the energy loss to each organ of the phantom is computed as well as a coefficient of variation (CV = 100 $\sigma/\bar{E}$) where σ is the standard deviation of the mean energy absorbed. There is no allowance for the spread of energy due to the drifting of the secondary electrons.

Even for a sample of 60,000 photons, the SAF for many organs is only poorly estimated. The policy used in earlier such calculations has been followed and all estimates for which the CV is an excess of 50% were rejected. This seems to amount to uncertainty by a factor of 2 or 3 in the estimate. Several alternatives may be tried in such cases, but the one of general application is to compute the SAF by use of Berger's point kernel for photons (Be68). This method, which ignores the inhomogeneities and

Table II

Specific absorbed fractions for walls of the gastro-intestinal tract and coefficients of variation (% rounded up) source in stomach wall

TARGET		ENERGY (MEV)											
		0.010		0.015		0.020		0.030		0.050		0.100	
ADRENALS	e	1.40E-10		b 2.10E-10		b 1.60E-07		7.00E-06	22	1.30E-05	12	1.29E-05	12
BLADDER	e	7.45E-18		b 1.12E-17		b 1.69E-11		b 3.61E-08		6.03E-07	35	9.76E-07	23
BRAIN	e	7.40E-33		b 1.11E-32		b 4.72E-19		b 6.16E-12		b 3.24E-09		2.77E-08	32
STOM W		5.44E-03	1	3.58E-03	1	2.27E-03	1	1.07E-03	1	4.23E-04	1	2.49E-04	1
SI W + C		4.19E-07	19	1.43E-06	1	3.75E-06	6	9.30E-06	1	1.36E-05	2	1.12E-05	2
LLI W		6.76E-07	38	5.62E-06	11	1.62E-05	6	2.43E-05	1	2.12E-05	3	1.58E-05	3
LLI W	e	8.46E-03		b 1.27E-08		8.65E-07	33	2.74E-06	11	5.22E-06	7	4.73E-06	6
HEART	e	7.27E-08		1.09E-08	62	5.71E-07	14	5.71E-06	5	1.04E-05	4	8.96E-06	3
KIDNEYS	e	1.22E-09		b 1.83E-09		5.58E-07	23	8.49E-06	7	1.53E-05	4	1.24E-05	4
LIVER	e	6.31E-09		9.48E-09	35	8.65E-07	9	8.69E-06	4	8.69E-06	2	7.56E-06	2
LUNGS	e	9.86E-07		1.48E-06	10	5.25E-06	5	1.08E-05	3	1.06E-05	3	7.79E-06	3
E.MARROW	e	1.33E-07		1.99E-07	9	1.18E-06	4	4.23E-06	2	9.07E-06	2	7.23E-06	2
T.MARROW	e	1.75E-07		2.62E-07	9	1.52E-06	4	5.02E-06	2	8.36E-06	2	5.76E-06	2
OTHER		2.24E-04	2	5.64E-06	1	8.13E-06	1	9.65E-06	1	7.61E-06	1	5.69E-06	1
OVARIES	e	8.64E-14		b 1.30E-13		b 2.11E-09		b 3.74E-07		1.76E-06	36	2.95E-06	27
PANCREAS		2.66E-06	32	6.05E-05	8	1.09E-04	5	1.57E-04	3	1.16E-04	3	7.17E-05	3
SKELETON		1.28E-07	1	1.92E-07	9	1.11E-06	4	3.50E-06	2	5.79E-06	2	4.09E-06	2
SKIN	e	6.86E-08		1.03E-07	21	6.49E-07	7	1.76E-06	4	2.08E-06	3	1.83E-06	3
SPLEEN	e	5.09E-07		7.64E-07	29	1.45E-05	7	5.59E-05	3	6.01E-05	3	3.89E-05	3
TESTES	e	1.12E-25		b 1.78E-25		b 3.56E-15		b 6.61E-10		b 6.13E-08		b 2.93E-07	
THYMUS	e	1.51E-17		b 1.51E-17		b 2.23E-11		b 9.44E-08		1.75E-06	28	1.25E-06	25
THYROID	e	1.98E-25		b 1.98E-25		b 8.30E-15		b 7.02E-10		b 6.36E-08		b 3.01E-07	
UTERUS	e	3.02E-15		b 4.54E-15		b 5.39E-10		b 2.44E-07		1.68E-06	17	2.84E-06	13
TOT.BODY		1.83E-05	1	1.83E-05	1	1.81E-05	1	1.29E-05	1	9.56E-06	1	6.72E-06	1
		0.200		0.500		1.000		1.500		2.000		4.000	
ADRENALS		1.80E-05	13	7.96E-06	21	7.46E-06	26	1.16E-05	17	1.18E-05	24	8.61E-06	41
BLADDER		1.07E-06	21	9.64E-07	32	5.86E-07	38	1.08E-06	38	2.75E-06	28	1.42E-06	42
BRAIN		5.22E-08	25	1.16E-07	23	1.58E-07	19	2.18E-07	17	2.13E-07	19	2.50E-07	18
STOM W		2.55E-04	2	2.70E-04	2	2.57E-04	2	2.29E-04	2	2.09E-04	2	1.71E-04	3
SI W + C		9.71E-06	3	9.72E-06	3	8.32E-06	4	8.13E-06	4	7.08E-06	4	6.86E-06	5
LLI W		1.39E-05	6	1.28E-05	5	1.20E-05	6	1.17E-05	7	1.06E-05	7	8.47E-06	8
LLI W		6.08E-06	7	6.92E-06	9	6.98E-06	11	6.13E-06	12	4.70E-06	12	2.82E-06	16
HEART		7.26E-06	8	7.47E-06	8	6.82E-06	5	6.94E-06	5	6.83E-06	6	4.98E-06	7
KIDNEYS		1.19E-05	8	1.13E-05	5	1.11E-05	6	1.08E-05	6	9.80E-06	5	7.25E-06	8
LIVER		7.20E-06	2	8.90E-06	3	6.47E-06	3	5.87E-06	4	5.60E-06	4	4.99E-06	4
LUNGS		6.69E-06	3	6.90E-06	4	6.34E-06	4	5.96E-06	5	5.44E-06	5	4.86E-06	6
E.MARROW		4.91E-06	2	3.76E-06	3	3.21E-06	3	3.05E-06	3	2.78E-06	3	2.86E-06	4
T.MARROW		3.66E-06	2	3.02E-06	2	2.63E-06	3	2.64E-06	3	2.51E-06	3	2.03E-06	4
OTHER		5.29E-06	1	5.26E-06	1	4.93E-06	1	4.70E-06	1	4.23E-06	1	3.73E-06	1
OVARIES		5.11E-06	30	2.75E-06	43	1.25E-06	46	2.89E-06	34	1.36E-06	41	b 2.88E-36	
PANCREAS		6.33E-05	8	6.07E-05	5	5.49E-05	6	4.82E-05	6	4.89E-05	7	3.80E-05	8
SKELETON		2.65E-06	2	2.15E-06	2	1.91E-06	2	1.86E-06	3	1.80E-06	3	1.69E-06	3
SKIN		1.70E-06	3	2.12E-06	4	2.09E-06	4	2.30E-06	4	2.05E-06	5	1.72E-06	5
SPLEEN		3.55E-05	3	3.23E-05	4	2.98E-05	5	2.61E-05	5	2.77E-05	-	2.05E-05	6
TESTES	b	4.38E-07		5.32E-07	1	b 5.05E-07		b 5.99E-07		b 6.02E-07		b 5.69E-07	
THYMUS		1.16E-06	26	1.28E-06	40	9.20E-07	38	5.44E-07	47	8.54E-07	65	2.74E-06	83
THYROID	b	4.07E-07		b 5.40E-07		b 5.91E-07		b 6.06E-07		b 6.12E-07		b 5.75E-07	
UTERUS		3.04E-06	13	2.97E-06	17	2.68E-06	18	2.64E-06	21	2.40E-06	23	2.50E-06	24
TOT.BODY		6.11E-06	1	6.06E-06	1	5.69E-06	1	5.31E-06	1	5.01E-06	1	4.17E-06	1

b - S.A.F. CALCULATED BY BUILD UP FACTOR METHOD

e - S.A.F. INTERPOLATED FROM HIGHER ENERGY

Table III

...ic absorbed fractions for walls of the gastro-intestinal tract and coefficients of variation ... rounded up) source in ...nner large intestine wall

TARGET		ENERGY (MEV)											
		0.010		0.015		0.020		0.030		0.050		0.100	
ADRENALS	e	1.11E-10		b 1.67E-10		b 1.35E-09		7.85E-08	40	3.89E-06	24	2.28E-06	29
BLADDER	e	5.69E-10		b 8.54E-10		b 1.48E-07		3.68E-06	16	8.48E-06	9	8.42E-06	8
BRAIN	e	8.10E-24		e 6.27E-24		b 8.36E-24	b	6.83E-14	b	2.23E-10	b	8.96E-09	
STOM W	e	4.67E-06		7.01E-06	12	1.68E-05	7	2.22E-05	5	2.16E-05	4	1.54E-05	4
SI W + C		9.70E-05	2	1.56E-04	1	1.96E-04	1	1.78E-04	1	1.10E-04	1	6.56E-05	1
ULI W		3.88E-03	1	2.56E-03	1	1.68E-03	1	7.91E-04	1	3.21E-04	1	1.92E-04	1
LLI W		2.11E-06	22	9.59E-06	10	1.84E-05	7	1.87E-05	5	1.57E-05	4	1.22E-05	4
HEART	e	1.31E-17		b 1.96E-17		b 1.56E-11		8.66E-08	38	5.80E-07	12	9.02E-07	9
KIDNEYS	e	7.19E-10		b 1.08E-09		3.82E-07	26	5.48E-06	7	1.13E-05	4	1.13E-05	4
LIVER	e	3.58E-07		5.38E-07	12	2.02E-06	6	7.96E-06	3	1.19E-05	2	1.01E-05	2
LUNGS	e	7.06E-18		b 1.06E-17		b 1.39E-11		8.51E-08	33	7.27E-07	8	6.79E-07	6
R.MARROW		8.88E-07	12	3.71E-06	6	1.05E-05	3	2.27E-05	2	2.74E-05	2	1.70E-05	2
Y.MARROW		1.63E-07	12	1.24E-07	4	3.53E-06	3	8.11E-06	2	1.11E-05	2	7.82E-06	2
OTHER		6.35E-07	3	2.26E-06	2	4.51E-06	1	7.55E-06	1	7.50E-06	1	5.85E-06	1
OVARIES	e	3.41E-05		5.12E-05	18	1.21E-04	11	9.26E-05	10	7.06E-05	8	4.61E-05	9
PANCREAS	e	6.28E-11		b 6.42E-11		b 5.93E-08		3.38E-06	16	8.57E-06	8	8.23E-06	8
SKELETON		1.16E-07	12	8.82E-07	4	2.51E-06	3	5.68E-06	2	7.62E-06	1	5.17E-06	1
SKIN	e	1.61E-09		b 2.72E-09		1.70E-07	14	1.05E-06	4	1.65E-06	3	1.68E-06	3
SPLEEN	e	1.19E-10		b 1.78E-10		b 6.19E-08		1.83E-06	18	5.23E-06	8	5.80E-06	6
TESTES	e	1.23E-17		b 1.85E-17		b 2.76E-11	b	4.80E-08		4.73E-07	37	1.03E-06	3
THYMUS	e	1.97E-26		b 2.96E-26		b 1.85E-15	b	5.59E-10	b	5.84E-08		2.93E-07	5
THYROID	e	6.65E-35		b 9.98E-35		b 1.80E-19	b	6.75E-12	b	4.03E-09	b	4.22E-08	
UTERUS	e	1.04E-08		b 1.56E-08		1.57E-06	31	1.60E-05	8	2.85E-05	5	2.12E-05	5
TOT.BODY		1.43E-05	1	1.43E-05	1	1.93E-05	1	1.35E-05	1	1.05E-05	1	7.56E-06	1
		0.200		0.500		1.000		1.500		2.000		4.000	
ADRENALS		3.34E-06	22	3.05E-06	38	3.88E-06	33	2.79E-06	48	3.91E-06	37	4.68E-06	36
BLADDER		8.10E-06	10	7.75E-06	13	8.93E-06	15	5.41E-06	33	9.01E-06	17	9.79E-06	23
BRAIN		1.28E-08	46	2.18E-08	43	3.58E-08	46	5.87E-08	34	5.94E-07	33	1.27E-07	25
STOM W		1.38E-05	5	1.28E-05	6	1.14E-05	8	1.08E-05	8	1.02E-05	9	9.96E-06	9
SI W + C		6.35E-05	1	6.12E-05	2	5.53E-05	2	5.07E-05	2	4.74E-05	1	3.55E-05	2
ULI W		1.95E-04	2	1.99E-04	2	1.81E-04	2	1.71E-04	2	1.61E-04	2	1.28E-04	3
LLI W		1.16E-05	5	1.20E-05	6	1.06E-05	7	9.65E-06	8	8.66E-06	9	6.78E-06	10
HEART		1.27E-06	9	1.38E-06	9	1.37E-06	10	1.30E-06	11	1.41E-06	11	1.38E-06	12
KIDNEYS		1.08E-05	4	9.44E-06	5	8.52E-06	6	8.69E-06	7	8.28E-06	7	7.30E-06	8
LIVER		9.36E-06	2	8.67E-06	3	8.32E-06	3	7.63E-06	3	7.05E-06	3	5.98E-06	4
LUNGS		9.78E-07	6	1.29E-06	7	1.38E-06	8	1.20E-06	9	1.26E-06	9	1.18E-06	10
R MARROW		1.02E-05	2	7.42E-06	2	6.78E-06	3	6.66E-06	3	5.79E-06	3	4.68E-06	3
Y.MARROW		4.57E-06	2	3.83E-06	2	3.21E-06	3	3.18E-06	3	2.86E-06	3	2.42E-06	3
OTHER		5.39E-06	1	5.27E-06	1	4.93E-06	1	4.69E-06	1	4.44E-06	1	3.66E-06	1
OVARIES		4.35E-05	11	3.41E-05	16	3.65E-05	17	2.99E-05	20	2.52E-05	22	2.46E-05	25
PANCREAS		7.30E-06	9	7.05E-06	12	6.69E-06	15	5.29E-06	17	6.13E-06	20	5.91E-06	18
SKELETON		3.22E-06	2	2.46E-06	2	2.26E-06	2	2.27E-06	2	2.05E-06	3	1.71E-06	3
SKIN		1.61E-06	3	1.96E-06	4	1.82E-06	4	1.91E-06	5	1.80E-06	5	1.70E-06	5
SPLEEN		6.59E-06	8	6.66E-06	9	3.36E-06	12	8.03E-06	12	3.62E-06	13	3.79E-06	13
TESTES		6.60E-07	38	8.27E-07	36	1.25E-06	40	1.63E-06	40	b 1.73E-06		1.36E-06	49
THYMUS		3.63E-07	43	b 5.28E-07		2.42E-07	48	b 5.98E-07		b 6.01E-07		b 5.66E-07	
THYROID	b	8.88E-08		b 1.44E-07		b 1.92E-07		b 2.18E-07		b 2.33E-07		b 2.49E-07	
UTERUS		2.00E-05	6	1.58E-05	8	1.79E-05	9	1.16E-05	11	1.41E-05	11	1.[illegible]E-05	13
TOT.BODY		6.78E-06	1	6.55E-06	1	6.10E-06	1	5.75E-06	1	9.51E-06	1	4.[illegible]E-06	1

b - S.A.F. CALCULATED BY BUILD UP FACTOR METHOD

e - S.A.F. EXTRAPOLATED FROM HIGHER ENERGY

SPECIFIC ABSORBED FRACTIONS

Table 11

Specific absorbed fractions for walls of the gastro-intestinal tract and coefficients of variation (% rounded up) source in lower large intestine wall

TARGET		ENERGY (MEV)											
		0.010		0.015		0.020		0.030		0.050		0.100	
ADRENALS	e	2.08E-17		b 3.12E-17		b 2.50E-11		b 3.50E-08		b 5.46E-07		1.16E-06	32
BLADDER	e	9.85E-07		1.48E-06	45	1.22E-05	13	3.72E-05	6	4.59E-05	4	3.25E-05	5
BRAIN	e	1.66E-25		e 2.52E-25		b 3.36E-25		b 5.67E-15		b 3.74E-11		b 1.18E-09	
STOM W	e	5.89E-09		b 8.24E-09		6.98E-07	33	2.73E-06	12	6.52E-06	7	5.00E-06	6
SI W + C		3.05E-05	3	6.25E-05	2	7.59E-05	2	7.07E-05	2	4.56E-05	2	3.08E-05	2
ULI W		2.50E-06	18	1.02E-05	8	1.81E-05	6	2.02E-05	4	1.46E-05	4	1.14E-05	1
LLI W		5.20E-03	1	7.67E-03	1	2.25E-03	1	1.02E-03	1	3.82E-04	1	2.35E-04	1
HEART	e	6.55E-22		b 9.82E-22		b 6.17E-14		b 1.32E-09		1.05E-07	28	2.38E-07	19
KIDNEYS	e	8.32E-12		b 1.25E-11		b 1.28E-08		7.34E-07	20	1.19E-06	8	2.91E-06	7
LIVER	e	3.59E-17		b 5.39E-17		b 1.90E-11		2.46E-08	33	4.03E-07	9	7.30E-07	6
LUNGS	e	1.97E-20		b 2.96E-20		b 3.66E-13		b 2.26E-09		9.50E-08	17	1.99E-07	12
L.MARROW		1.96E-04	6	1.10E-05	3	2.73E-05	2	5.07E-05	1	4.45E-05	1	2.16E-05	1
T.MARROW		6.53E-07	6	3.66E-06	3	9.11E-06	2	1.72E-05	1	1.63E-05	1	8.52E-06	1
OTHER		9.83E-07	2	3.53E-06	1	6.80E-06	1	9.79E-06	1	8.88E-06	1	6.88E-06	1
OVARIES	e	5.77E-05		8.66E-05	14	1.38E-04	10	1.40E-04	8	8.74E-05	8	4.73E-05	9
PANCREAS	e	1.38E-14		b 2.08E-14		b 8.75E-10		b 2.33E-07		2.10E-06	17	1.70E-06	15
SKELETON		4.66E-07	4	2.61E-06	3	6.98E-06	2	1.29E-05	1	1.31E-05	1	7.49E-06	1
SKIN		9.09E-08	26	2.24E-07	15	5.64E-07	8	1.82E-06	6	2.11E-06	3	1.97E-06	3
SPLEEN	e	1.65E-12		b 2.48E-12		b 6.25E-09		6.79E-07	26	1.56E-06	12	2.43E-06	9
TESTES	e	1.17E-09		b 1.76E-09		8.89E-07	43	7.88E-06	15	1.45E-05	9	9.38E-06	10
THYMUS	e	5.31E-30		b 7.97E-30		b 1.80E-17		b 3.32E-11		b 7.93E-09		b 6.04E-08	
THYROID	e	5.08E-38		b 7.63E-38		b 2.92E-20		b 5.36E-13		b 6.51E-10		b 9.93E-09	
UTERUS	e	5.65E-07		b 8.49E-09		1.02E-06	28	1.99E-05	7	3.32E-05	5	2.86E-05	5
TOT.BODY		1.83E-05	1	1.83E-05	1	1.83E-05	1	1.37E-05	1	1.08E-05	1	5.02E-06	1

TARGET		0.200		0.500		1.000		1.500		2.000		4.000	
ADRENALS		5.78E-07	91	b 1.43E-06		b 1.40E-06		b 1.34E-06		b 1.30E-06		b 1.16E-06	
BLADDER		2.73E-05	6	2.06E-05	8	2.20E-05	9	1.98E-05	11	8.39E-06	12	1.78E-05	13
BRAIN	b	8.53E-06		b 1.31E-08		b 2.62E-08		b 3.63E-08		5.38E-08	38	6.37E-08	36
STOM W		5.25E-06	8	4.22E-06	10	3.66E-06	12	4.69E-06	12	3.50E-06	14	3.61E-06	15
SI W + C		2.83E-05	2	2.75E-05	2	2.41E-05	2	2.30E-05	3	2.13E-05	3	1.78E-05	3
ULI W		1.06E-05	5	1.16E-05	6	9.96E-06	7	9.20E-06	7	9.08E-06	8	6.97E-06	9
LLI W		2.42E-04	2	2.56E-04	2	2.38E-04	2	2.18E-04	2	2.02E-04	2	1.53E-04	3
HEART		2.97E-07	15	3.92E-07	18	5.01E-07	17	5.29E-07	18	5.50E-07	17	4.60E-07	19
KIDNEYS		2.73E-06	8	3.16E-06	9	3.13E-06	10	2.53E-06	12	2.84E-06	12	2.81E-06	12
LIVER		8.47E-07	6	9.89E-07	6	9.95E-07	7	1.11E-06	7	1.12E-06	7	1.22E-06	8
LUNGS		1.90E-07	12	9.03E-07	12	4.11E-07	14	6.25E-07	12	5.26E-07	13	5.39E-07	15
R.MARROW		1.41E-05	2	1.10E-05	2	9.91E-06	2	9.36E-06	3	8.92E-06	3	7.36E-06	3
T.MARROW		5.56E-06	2	4.48E-06	2	4.02E-06	2	3.85E-06	2	3.57E-06	3	3.06E-06	3
OTHER		6.33E-06	1	6.19E-06	1	5.80E-06	1	5.67E-06	1	5.17E-06	1	4.23E-06	1
OVARIES		6.48E-05	11	3.61E-05	14	4.57E-05	16	5.20E-05	17	2.16E-05	24	3.00E-05	22
PANCREAS		2.93E-06	14	2.40E-08	20	2.34E-06	22	1.69E-06	29	2.05E-06	28	1.28E-06	37
SKELETON		4.89E-06	1	3.86E-06	2	3.46E-06	2	3.33E-06	2	3.07E-06	2	2.69E-06	3
SKIN		1.95E-06	3	2.05E-06	4	2.32E-06	4	2.22E-06	4	1.96E-06	5	1.79E-06	5
SPLEEN		2.75E-06	10	2.28E-06	13	2.32E-06	14	2.69E-06	15	2.87E-06	15	2.33E-06	17
TESTES		8.27E-06	11	6.72E-06	15	7.26E-06	18	6.55E-06	19	7.47E-06	19	6.33E-06	26
THYMUS	b	1.12E-07		b 1.68E-07		b 2.15E-07		b 2.39E-07		b 2.51E-07		b 2.61E-07	
THYROID	b	2.59E-08		b 5.19E-08		b 8.06E-08		b 9.80E-08		b 1.11E-07		b 1.30E-07	
UTERUS		2.34E-05	5	1.87E-05	7	1.58E-05	9	1.52E-05	10	1.65E-05	10	9.70E-06	13
TOT.BODY		6.79E-06	1	6.58E-06	1	6.13E-06	1	5.77E-06	1	5.43E-06	1	4.66E-06	1

b - S.A.F. CALCULATED BY BUILD UP FACTOR METHOD

e - S.A.F. INTERPOLATED FROM HIGHER ENERGY

boundaries of the body, is almost never in error by more than a factor of 2 and is usually accurate to within 30-50% (Sn74). It has been used, where necessary, to produce the values of SAF tabulated below. Unfortunately, Berger has not given a point kernel for photons of energy 10 keV and, thus, such values have to be obtained by extrapolation from a higher energy. Here, only a linear extrapolation is used, although this is believed to be conservative.

4 – TABLES OF SAF

The values of SAF are tabulated in Tables II-IV together with an indication of its CV. The CV is given as estimated by the Monte Carlo calculation. However, for values obtained by the build-up factor or by extrapolation, no value of the CV is given since the procedure used involves systematic errors as well as statistical errors and, in these cases, the CV would not indicate a measure of the uncertainty.

The SAF is tabulated for the stomach wall, upper large intestinal wall and the lower large intestinal wall as source organs and with all the usual target organs. The above source organs are abbreviated as STOM W, ULI W, LLI W in Table II and similar abbreviations have been used for other organs. As mentioned above, the small intestine has not been used as a source, but the SAF for the contents, given in ORNL-5000, Part 1, may be used as an average for the walls due to the movement of the small intestine. The foot-notes indicate whether a value is obtained by the Monte Carlo calculation, by use of the build-up factor, or by extrapolation. In these latter two cases, no coefficient of variation is given as is mentioned above.

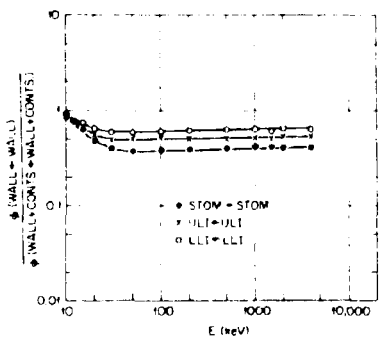

Figure 1 – Ratio of absorbed fractions (target: GI tract)

Figure 1 shows a comparison of the new values of SAF as computed from a wall of the GIT to itself, SAF (wall ← wall), and the similar values of the SAF for the contents plus the walls. This gives a comparison of the new values with the old, that is, with the values given in MIRD Pamphlet No. 5.

The ratio of the SAF (X ← wall) to SAF (X ← wall plus content) where X is an outside organ, that is, not a part of the GI tract, is shown. Figure 2 contains this ratio for X = liver and Figure 3 for X = lungs by way of example. There seems to be no evident systematic difference in the absorbed fraction from the wall to an outside organ such as liver or lungs and the absorbed fraction from the wall plus contents to the similar organs. The values of the ratio are approximately equal to 1 throughout most of the range, say for energies above 30 keV. At lower energies there is increasing divergence but this we attribute to minor changes in the phanton which were made in the years between the two calculations and to the effect of the CV which is generally high. Thus one could continue to use the older absorbed fractions from sections of the GI tract to an outside organ for most of these energies instead of the newer values. However, we believe the new velues are somewhat more accurate than the old.

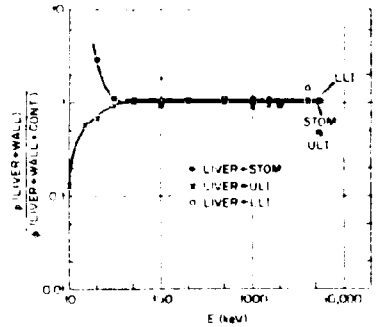

Figure 2 – Ratio of absorbed fractions (target: liver)

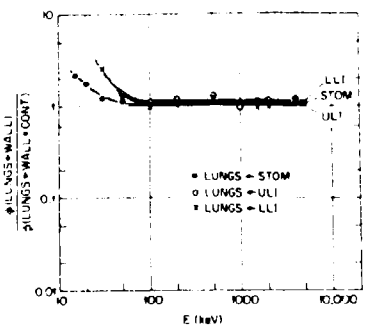

Figure 3 – Ratio of absorbed fractions (target: lungs)

The estimation of all these values was performed using the IBM-370/155 computer at the Institute de Energia Atomica at Sao Paulo, Brazil. Although the basic code originated at Oak Ridge National Laboratory and although several check runs were made to insure that it was correctly used, all the calculations were done at Sao Paulo. It is hoped that the availability of these values will encourage radiobiologists to compile data on the presence of a radionuclide in the walls of the GIT.

REFERENCES

Be68 Berger M. J., 1968, "Energy Deposition in Water by Photons from Point Isotropic Sources," MIRD Pamphlet No. 2, *J. nucl. Med., Suppl.* No. 1.

Ha62 Harper P. V., Andros G. and Lathrop K., 1962, *Argonne Cancer Research Hospital* 18 76.

Mc64 McAfee J. C., Fueger C. E., Stern H. S., Wagner H. N., Jr. and Migita T., 1964, *J. nucl. Med.* 5, 811.

MIRD73 MIRD Dose Estimate Report No. 2, 1973, "Summary of Current Radiation Dose Estimates to Humans from ^{66}Ga ^{67}Ga, ^{68}Ga and ^{72}Ga Citrate," *J. nucl. Med.* 14, 10.

Sn69 Snyder W. S., Ford M. R., Warner G. G. and Fisher H. L., Jr., 1969, "Estimates of Absorbed Fractions for Monoenergetic Photon Sources Uniformly Distributed in Various Organs of a Heterogeneous Phantom," MIRD Pamphlet No. 5, *J. nucl. Med., Suppl*, No. 3, 10

Sn74 Snyder W. S., Ford M. R., Warner G. G. and Watson S. B., 1974, A Tabulation of Dose Equivalent per Microcurie-Day for Source and Target Organs of An Adult for Various Radionuclides, Oak Ridge National Laboratory Report, Ornl-5000.

Sn75 Snyder W. S., Chairman, 1975, Report of the Task Group on Reference Man, ICRP Report No. 23 (Pergamon Press).

Sn76 Snyder W. S., Ford M. R. and Werner G. G., 1977 Estimates of Specific Absorbed Fractions for Radiation Sources Uniformly Distributed in Various Organs of a Heterogeneous Phantom, MIRD Pamphlet No. 5 – Revised New York, Society of Nuclear Medicine.

Sm65 Smith E. M., 1965, *J. nucl. Med.* 6, 231.

INSTITUTO DE ENERGIA ATÔMICA
Caixa Postal, 11049 – Pinheiros
CEP 05508
01000 – São Paulo – SP

Telefone: 211-6011
Endereço Telegráfico – IEATOMICA
Telex – 011-23592 IENA BR