^{166m}Ho - Comments on evaluation of decay data
by E. Schönfeld, R. Dersch
(Half-life updated, M.-M. Bé, May 2012)

This decay scheme was updated in June 2006, in order to improve the balance of the decay scheme. Two gamma-rays with energy 712 (12,5) and 736-keV (15,7) were added see § 2.2. (M.-M. Bé, LNHB).

The half-life was also updated in May 2012 to include the new measurement of 2012Ne05 (M.-M. Bé, LNHB).

1 Decay Scheme

The decay scheme was taken from Ardisson *et al.* 1992. It contains 56 gamma transitions between 17 excited levels of ^{166}Er or to the ground state of this nuclide. This decay scheme is not complete. 10 additional gamma rays have been reported, six of them from branching in Tm-166 EC decay (see 2.2).

The half-lives of the excited level in ^{166}Er indicated in the decay scheme are taken from Shursikow and Timofeeva (1992).

2 Nuclear Data

The half-life was first determined by Faler (1965) to be 1200 a. The uncertainty was estimated to be 180 a. The Q-value is 6,0 keV above Q(^{166}Ho). This is the energy difference between the isomer level and the ground state of ^{166}Ho. The Q-value of ^{166}Ho was derived from ß-ray endpoint energies to be 1854,5 (9) keV. Thus, the Q-value of ^{166m}Ho is 1860,5 (9) keV.

A new half-life measurement by Nedjadi et al. (2012Ne05) gave a value of 1132.6 (39) a. Considering the measured uncertainty only appears to include statistical components, the uncertainty has been doubled in order to attempt to include a systematic component, giving **1133 (8) a**, which is also adopted as the recommended value. New measurements are still desirable.

2.1 $ß^-$ Transitions

There are seven ß transitions to excited levels of ^{166}Er. The most important transitions are the allowed transitions to levels no. 17 and 16 (17,2 (4) % and 74,8 (12) %). Weak transitions are feeding the levels 11, 10, 9, 6 and 3. Transitions to the levels 15, 14, 13, 12, 8, 7, 5, 4, 2, 1 and the ground state ($\Delta J_o = 7$) have not been observed. All these transitions are at least second forbidden except a transition to level 8 which is unique first forbidden.

The energies of these transitions were calculated by subtracting the level energy from the Q-value. The transition probabilities $P_ß$ were calculated from the transition probabilities $P_{\gamma+ce}$ using the relations which correspond to the decay scheme.

2.2 Gamma transitions

The level differences are equal to the gamma-ray energies as the recoil energies are small compared with the uncertainties of the latter. The gamma-ray energy of the 80,6 keV emission has been determined as follows (energy in keV):

1	80,573	Reich and Cline 1970
2	80,589 (5)	Morii et al. 1975
3	80,572 (15)	Souch et al. 1982
4	80,585 (15)	Adam et al. 1988
5	80,574 (8)	Hardell and Nilsson 1962; cryst.-spectr.
6	80,5725 (13)	Helmer and van der Leun 2000; here also adopted

The energies of gamma transitions between the levels 0, 1, 2, 3, 5, 6, 7, 8, 9, 10 and the transitions $\gamma_{16,5}$ and $\gamma_{17,3}$ are taken from Helmer and van der Leun (2000). The energies of all other transitions are either taken from Ardisson *et al.* (1992) or based on values given by these authors.

The probabilities $P_{\gamma+ce}$ were calculated from the gamma-ray emission probabilities P_γ using the values for the total conversion coefficients α_t. The conversion coefficients α_K , α_L and α_t were interpolated from the tables of Rösel *et al.* (1978). The normalization factor which is necessary to convert relative emission probabilities (related to 100 for the 184 keV gamma rays) can be calculated from balancing conditions using cuts between the levels 0 and 1, 1 and 2, 2 and 3. This is possible because the levels 2, 1 and 0 (the ground state) are not populated by β transitions. The cut between the levels 0 and 1 contains the emission probability of the 80,6 keV gamma transition. The conversion coefficient of this transition has a relatively large uncertainty, the calculation of the normalization factor from the cuts 1-2 and 2-3 is therefore preferred here. Moreover, the normalization factor was determined using absolute activity measurements:

1	0,732 (37)	Reich and Cline, 1970
2	0,699 (14)	Danilenko et al., 1989
3	0,7258 (22)	Miyahara et al., 1994
4	0,7021 (35)	Morel et al., 1996
5	0,7235 (67)	Hino et al., preliminary value, 1999
6	0,7214 (72)	from cut between levels 1 and 2, this evaluation 1999
7	0,7298 (75)	from cut between levels 2 and 3, this evaluation 1999
8	0,725 (3)	adopted value

The value 8 is the LWM between values 1, 3, 5, 6 and 7 where the uncertainty of value 3 has been doubled in order to contribute less than 50% to the mean. Values 2 and 4 are considered to be significantly too low by the evaluator and were not included in the averaging procedure. The reduced χ^2 of the LWM is 0,2. The adopted value of the normalization factor is in excellent agreement with the value 0,726 (9) evaluated by Shursikow and Timofeeva (1992).

The K-conversion coefficients were calculated using the tables of Rösel et al. (1978). The multipolarities of the transitions were determined from the spin and parity assignments as made by Ardisson *et al.* (1992) and Shursikow and Timofeeva (1992). There is reasonable agreement between measured and calculated conversion coefficient for the 80,6 keV transition:

1	1,76 (15)	Marklund et al. 1960
2	1,72 (6)	Nelson and Hatch 1969
3	1,69 (6)	Campbell et al. 1971
4	1,65 (3)	E2 Theory, Rösel et al. 1978

The following gamma rays are not included in the decay scheme and in the tables 2.2 and 4.2:

E_γ in keV	P_{rel} (related to 100 for the 184,4 keV line)	
96,85 (5)	0,00307	*
170,31 (3)	0,0184 (11)	*
255,20 (12)	0,0059 (13)	
410,80 (5)	0,0231 (7)	*
520,945 (15)	0,00039 (7)	*
617,0 (5)	0,031 (9)	
1446,72 (13)	< 0,01	
1521,99 (4)	0,018 (5)	
1562,57 (4)	0,0040 (11)	

Even though they are not well established in the Ho-166m decay, the two following gamma rays have been included in the decay scheme. There presence is suggested by a better consistency in the level balance, especially for the 1572 keV level.

712,89 (13)	0,41 (12)	*
736,02 (8)	0,19 (2)	

* Deduced from branching in Tm-166 EC decay where also the 73 keV transition, contained in Table 2, occurs. These data are taken from Shursikow and Timofeeva (1992), see also Adam et al. (1979).

For several transitions, mixing ratios were determined from γ-γ angular correlation measurements. Most of them are compiled in the following table:

E2-M1 mixing ratios for γ-transitions in ^{166}Er following the decay of ^{166m}Ho

E_r in keV	δ	δ(adopted)	% M1
119,0	±1,79(12)[1] 1,75(12)[2]	1,79 (12)	24 (2)
140,7	±1,43(10)[1] 1,67(11)[2]	1,43 (10)	33 (3)
160,1	1,45(11)[1]	1,45 (11)	32 (4)
464,8	-(3,1+1,5-0,9)[3] -80<δ<+30[4] -(32+98-14)[5]		
	-(63+19-12)[6]	-50 (20)	(0,04 + 0,07 - 0,02)
529,8	-(85+∞-45)[7] -25(3)[4] -5,0(25)[3]		
	-(25+5-4)[5] -(62+40-17)[8] -(60+45-19)[8]	-30 (20)	(0,11 + 0,9 - 0,07)
594,1	-(9+319-5)[4] (9+∞-5)[5] -(12+29-5)[8]		
	-(8+15-3)[8] -(59+74-21)[2]	-10 (5)	(1 + 3 - 0,5)
644,5	|δ|>2[4] +1,6+1,0-0,55[3] -0,75(20)[3]		
	<-1or >+4[8] -(13,4+3,3-2,2)[2]	3 - 2 + 3	(10 + 40 - 7)
670,5	6,3+∞-2,9[3] -(1,15+0,80-0,35)[3]		
	-(20+90-9)[4, 5] (10,0+1,6-1,2)[8]		
	9,4+2,9-1,6[8] (19+5-3)[2]	12 (5)	(0,69 + 1,31 - 0,35)
691,3	3,3+3,0-1,2[9] -(10+27-4)[4] -(16+27-4)[5]		
	-(28+7-5)[2] -(16+∞-9)[8] -(16+∞-10)[8]	-16 (8)	(0,39 - 0,22 + 1,15)
705,2	|δ|≥25[10] 38+∞-24[9] 19+38-9[9]		
	-(55+13-9)[2]	50 (10)	(0,04 + 0,02 - 0,01)
778,8	-(20+∞-13)[3] -(18+∞-9)[4] -(19+∞-10)[5]		
	-(20+4-2)[8] -(18+8-5)[8] -(109+26-17)[2]	18 (6)	(0,31 + 0,35 - 0,14)
810,3	37+10-7[7] -16,4+3,2-2,3[11] -20(4)[4]		
	-(84+∞-57)[3] -(20+4-3)[5] -(36+11-7)[6]		
	-21(2)[8] -15(1)[8]	25 (5)	(0,16 + 0,09 - 0,05)
830,6	70+260-30[7] -(42+25-13)[11] -(22+7-5)[4,5]		
	-(37+∞-17)[3] -(18+3-2)[6] -23(4)[8]		
	-(16,6+1,8-1,5)[8] -(15,3+2,3-1,7)[2]	-(18 + 3 - 2)	0,31 (8)

[1]	Wagner 1992, measured
[2]	Wagner 1992, calculated
[3]	West et al. 1976
[4]	Baker et al. 1975
[5]	Lange et al. 1981
[6]	Alzner et al. 1985
[7]	Reich and Cline 1965
[8]	Krane and Moses 1981
[9]	Domingos et al. 1972
[10]	McGowan et al. 1978
[11]	Miyokawa et al. 1972 as cited in the paper of Krane and Moses 1981

Some of the measurements are discrepant. However, the influence of the results on the conversion coefficients is in most cases small. Gerdau *et al.* (1963) determined some mixing ratios from γ-γ-angular correlations. Some of them deviate from the results of later publications (411 keV 95 % E1 + 5 % M2; 712 keV 99,6 % E1 + 0,4 % M2; 810 keV 99,1 % E2 + 0,9 % M1; 831 keV 96,1 % E2 + 3,9 % Ml).

If two multipolarities are mentioned in Table 2.2, then the mixing ratio was taken into account when calculating the conversion coefficients. If a second multipolarity is given in brackets, then the conversion coefficients are calculated for the first multipolarity but an admixture of the second multipolarity is not ruled out.

3 Atomic Data

The atomic data are taken from Schönfeld and Janßen (1996).

3.1 X Radiations

The energies are based an the wavelengths of Bearden (1967). The relative probabilities are taken from Schönfeld and Janßen (1996). The relative probability of the L X rays is calculated from the absolute value (Table 4) setting $P(K_{\alpha1}) = 1$.

3.2 Auger electrons

The energies are taken mainly from Larkins (1977). The relative probabilities are taken from Schönfeld and Janßen (1996). The relative probability of the L Auger electrons is calculated from the absolute value (Table 4) setting $P(\text{KLL}) = 1$

4 Radiation Emissions

4.1 Electron Emissions

The energies of the Auger electrons are the same as in 3.2. The energies of the conversion electrons are calculated from the transition energy (2.2) and the binding energies. The emission probabilities of the Auger electrons are calculated from P_γ's and conversion coefficients using the program EMISSION (PTB, 1997).

The emission probabilities of the conversion electrons are calculated using the conversion coefficients given in Table 2.2, the atomic data given in Section 3, and the emission probabilities of the gamma rays given in Table 4.2.

4.2 Photon Emissions

The energies of the X rays are the same as in Table 3.1. Measured KX-ray emission probabilities (Chand *et al.* 1988, Morel *et al.* 1996) are in good agreement with the calculated values. If the measured values are related to the here adopted emission probability of the 184-keV gamma rays, the following values are obtained (quanta per 100 disintegrations):

	E in keV	P_X (Chand)	P_X(Morel)	P_X(calc)
Er $K_{\alpha2}$	48,221	10,95 (23)	10,63 (8)	10,81 (21)
Er $K_{\alpha1}$	49,128	18,4 (3)	19,17 (13)	19,2 (4)
Er $K'_{ß1}$	55,624	5,70 (9)	6,03 (5)	6,24 (14)
Er $K'_{ß2}$	57,239	1,41 (3)	1,594 (20)	1,62 (5)

The calculated emission probabilities of the X-rays (calculated from Pγ's and conversion coefficients using the program EMISSION (PTB, 1997)) are compiled in the last column.

The energies of the gamma rays are taken either from Helmer and van der Leun (2000) or from Ardisson *et al.* (1992) (see Sect. 2.2). Their uncertainties are to be considered as standard uncertainties.

The relative emission probabilities of gamma rays (related to 100 for the emission probabilities of the 184,4 keV transition $\gamma_{2,1}$) as measured by 17 authors are compiled in the following table. The last column in this table contains the LWM except of $\gamma_{1,0}$ where balance conditions are taken into account. The transition probability of the transition $\gamma_{1,0}$ is very well known as there is only one other transition to the ground state which is very weak ($\gamma_{4,0}$):

$$f_N \, [P_{rel}(\gamma_{1,0}) \, (1 + \alpha_t) + P_{rel}(\gamma_{4,0}) \, (1 + \alpha_t)] = 100$$

The conversion coefficient is, of course, to be included for the assigned gamma transition. This yields for the transition $\gamma_{1,0}$

$$P_{\gamma+ce} = 100 - f_N \, P_{rel}(\gamma_{4,0}) \, (1 + \alpha_t)$$

With f_N = 0,725 (3), $P_{rel}(\gamma_{4,0})$ = 0,026 (5), α_t ($\gamma_{4,0}$) = 0,00566 (12)

we obtain :

$$P_{\gamma+ce}(\gamma_{1,0}) = 99{,}981 \ (4) \text{ per 100 disintegrations.}$$

With the conversion coefficient of the transition $\gamma_{1,0}$ this yields:

$$P_\gamma \ (\gamma_{1,0}) = 12{,}66 \ (23) \text{ per 100 disintegrations, in relative units: } 17{,}46 \ (31).$$

Gamma relative emission intensities, references 1 to 6 :

$\gamma_{i,f}$	E_γ (keV)	1	2	3	4	5	6
$\gamma_{1,0}$	80,577 (7)	14,5 (29)	14,55 (47)	17,1 (9)	14,48 (48)	16,83 (42)	16,7 (10)
$\gamma_{16,15}$	94,679 (9)	0,16 (3)$^{1)}$	-	0,19 (1)	0,3	0,21 (3)	-
$\gamma_{8,7}$	119,035 (10)	-	-	0,24 (3)	-	0,23 (3)	-
$\gamma_{16,14}$	121,175 (10)	0,7 (5)$^{1)}$	-	0,36 (5)	0,78 (18)$^{1)}$	0,54 (5)$^{1)}$	-
$\gamma_{17,15}$	135,257 (14)	0,1 (1)	-	0,14 (2)	-	-	-
$\gamma_{9,8}$	140,702 (20)	-	-	0,059 (14)	-	-	-
$\gamma_{10,9}$	160,077 (20)	0,35 (10)	-	0,134 (16)	0,36 (15)$^{1)}$	0,16 (3)	-
$\gamma_{17,14}$	161,707 (14)	-	-	0,15 (2)	-	0,16 (3)	-
$\gamma_{2,1}$	184,4107 (11)	100	100	100	100	100	100
$\gamma_{16,13}$	190,747 (16)	-	-	0,30 (3)	-	0,31 (4)	-
$\gamma_{16,12}$	214,79 (3)	-	-	0,75 (10)$^{1)}$	-	-	-
$\gamma_{8,5}$	215,871 (10)	3,8 (4)	4,15 (7)	3,6 (4)	3,94 (9)	3,96 (8)	4,1 (2)$^{2)}$
$\gamma_{17,13}$	231,32 (4)	0,3 (2)	0,32 (5)	0,33 (4)	0,36 (3)$^{1)}$	0,31 (4)	-
$\gamma_{9,7}$	259,70 (3)	1,8 (5)$^{1)}$	1,42 (10)	1,50 (11)	1,77 (12)$^{1)}$	1,52 (5)	-
$\gamma_{3,2}$	280,468 (7)	39,5 (28)	43,6 (6)$^{1)}$	40,7 (29)	38,61 (46)	39,63 (126)	40,2 (18)
$\gamma_{10,8}$	300,741 (3)	4,8 (4)	5,45 (8)	5,12 (37)	4,77 (9)	4,92 (12)	4,97 (22)
$\gamma_{9,6}$	305,03 (5)	-	-	-	-	-	-
$\gamma_{11,9}$	339,75 (5)	-	-	0,23 (3)	-	0,23 (4)	-
$\gamma_{6,3}$	365,736 (9)	2,9 (3)$^{1)}$	3,72 (8)	3,44 (25)	2,93 (6)	3,25 (10)	3,30 (11)
$\gamma_{16,10}$	410,956 (3)	15,8 (12)	16,8 (3)$^{1)}$	15,8 (12)	15,50 (19)	14,77 (30)	15,27 (50)
$\gamma_{17,10}$	451,540 (4)	3,5 (7)	4,30 (9)	4,18 (30)	3,48 (7)$^{1)}$	3,84 (13)	3,99 (13)
$\gamma_{10,6}$	464,819 (12)	2,0 (4)	1,66 (8)	1,68 (14)	2,00 (7)	1,50 (8)	-
$\gamma_{15,9}$	476,38 (6)	0,4 (2)$^{1)}$	-	-	-	-	-
$\gamma_{12,8}$	496,86 (4)	-	-	-	-	-	-
$\gamma_{4,2}$	520,85 (5)	-	-	-	-	-	-
$\gamma_{8,3}$	529,825 (4)	10,3 (10)$^{1)}$	13,00 (42)	13,9 (10)	10,16 (32)$^{1)}$	12,36 (25)	12,78 (42)
$\gamma_{16,9}$	570,995 (5)	6,8 (7)	7,08 (16)	7,86 (56)	6,77 (14)	7,04 (14)	7,45 (24)
$\gamma_{5,2}$	594,536 (24)	1,2 (4)$^{1)}$	0,74 (10)	0,96 (8)$^{1)}$	1,28 (18)$^{1)}$	0,70 (5)	-
$\gamma_{17,9}$	611,620 (17)	1,4 (10)	1,59 (32)	1,90 (15)	1,48 (27)	1,67 (9)	-
$\gamma_{12,7}$	615,84 (9)	-	-	-	-	-	-
$\gamma_{13,7}$	639,97 (9)	-	-	0,22 (7)$^{1)}$	-	-	-
$\gamma_{11,6}$	644,689 (15)	0,27 (15)	0,31 (105)$^{1)}$	0,25 (3)	-	-	-
$\gamma_{9,3}$	670,526 (4)	7,0 (7)	7,35 (30)	7,88 (56)	7,01 (25)	6,98 (16)	7,37 (24)
$\gamma_{7,2}$	691,304 (12)	1,9 (4)	1,62 (8)	2,09 (15)$^{1)}$	1,85 (9)	1,60 (10)$^{1)}$	1,800 (59)
$\gamma_{4,1}$	705,09 (7)	-	-	-	-	-	-
$\gamma_{16,8}$	711,697 (3)	72,5 (60)	71,5 (10)	80,2 (57)$^{1)}$	71,65 (68)	71,10 (142)	74,5 (25)
$\gamma_{13,5}$	736,70 (7)	0,45 (15)	0,50 (5)	0,14 (5)$^{1)}$	0,46 (4)	0,45 (5)	-
$\gamma_{17,8}$	752,280 (4)	16,1 (12)	15,20 (34)$^{1)}$	17,9 (13)	16,06 (40)	15,98 (32)	16,57 (54)
$\gamma_{5,1}$	778,827 (6)	3,8 (3)	3,88 (7)	4,51 (33)	3,72 (7)	4,16 (12)	4,13 (13)
$\gamma_{4,0}$	785,81 (7)	-	-	-	-	-	-
$\gamma_{8,2}$	810,286 (4)	76 (8)	76,40 (110)	85,7 (61)$^{1)}$	76,38 (82)	75,71 (151)	78,1 (28)
$\gamma_{10,3}$	830,565 (4)	12,5 (10)	12,90 (32)	14,5 (11)	12,07 (28)	12,83 (26)	13,26 (44)
$\gamma_{7,1}$	875,663 (7)	1,15 (15)	0,91 (4)	1,08 (10)	1,14 (7)	1,00 (9)	0,979 (32)
$\gamma_{9,2}$	950,988 (4)	3,6 (6)	3,16 (13)$^{1)}$	4,15 (30)$^{1)}$	3,50 (14)$^{1)}$	3,74 (16)	3,68 (12)
$\gamma_{11,3}$	1010,27 (6)	-	0,11 (340)	0,12 (2)	-	-	-
$\gamma_{14,3}$	1120,35 (5)	-	0,26 (2)	0,31 (3)	0,30	-	-
$\gamma_{15,3}$	1146,81 (9)	0,38 (6)$^{1)}$	0,26 (2)	0,30 (3)	0,38 (5)$^{1)}$	-	0,274 (9)
$\gamma_{16,3}$	1241,519 (4)	1,25 (25)	1,06 (4)	1,37 (10)$^{1)}$	1,22 (5)	1,17 (12)	1,098 (37)
$\gamma_{17,3}$	1282,102 (5)	0,80 (15)$^{1)}$	0,22 (2)	0,31 (3)	0,38 (4)$^{1)}$	0,24 (5)	0,241 (8)
$\gamma_{12,2}$	1306,60 (15)	-	-	-	-	-	-
$\gamma_{13,2}$	1331,04 (13)	-	-	-	-	-	-
$\gamma_{14,2}$	1400,79 (2)	0,93 (9)$^{1)}$	0,72 (2)	0,75 (6)	0,86 (5)$^{1)}$	-	0,670 (22)
$\gamma_{15,2}$	1427,24 (2)	0,69 (7)	0,69 (2)	0,81 (6)$^{1)}$	0,65 (3)	-	0,665 (23)
-	1446,7 (2)	-	-	-	-	-	-

Gamma relative emission intensities, references 7 to 12 :

$\gamma_{i,f}$	E_γ (keV)	7	8	9	10	11	12
$\gamma_{1,0}$	80,577 (7)	17,51 (61)	16,56 (8)	17,8 (4)	16,97 (13)	17,2 (8)	16,59 (39)
$\gamma_{16,15}$	94,679 (9)	0,221 (12)	-	0,22 (1)	0,20 (1)	0,190 (26)	-
$\gamma_{8,7}$	119,035 (10)	0,222 (12)	-	0,27 (2)1)	0,24 (1)	0,243 (13)	-
$\gamma_{16,14}$	121,175 (10)	0,337 (15)	-	0,45 (2)1)	0,35 (2)	0,346 (14)	-
$\gamma_{17,15}$	135,257 (14)	0,126 (10)	-	0,14 (1)	0,14 (1)	0,128 (6)	-
$\gamma_{9,8}$	140,702 (20)	0,059 (9)	-	0,06 (1)	0,07 (1)	0,060 (4)	-
$\gamma_{10,9}$	160,077 (20)	0,109 (8)	-	0,14 (1)	0,14 (2)	0,124 (4)	-
$\gamma_{17,14}$	161,707 (14)	0,135 (8)	-	0,15 (1)	0,15 (2)	0,140 (7)	-
$\gamma_{2,1}$	184,4107 (11)	100	100	100	100	100	100
$\gamma_{16,13}$	190,747 (16)	0,304 (15)	-	0,31 (1)	0,33 (2)	0,291 (10)	-
$\gamma_{16,12}$	214,79 (3)	0,586 (23)	-	0,61 (2)	0,61 (2)	-	0,60 (5)
$\gamma_{8,5}$	215,871 (10)	3,54 (13)	4,04 (4)	3,67 (9)	3,60 (13)	4,14 (17)2)	3,61 (13)
$\gamma_{17,13}$	231,32 (4)	0,284 (15)	-	0,30 (1)	0,33 (3)	0,289 (11)	0,263 (20)
$\gamma_{9,7}$	259,70 (3)	1,446 (52)	-	1,53 (3)	1,52 (3)	1,47 (5)	1,50 (5)
$\gamma_{3,2}$	280,468 (7)	40,79 (141)	41,26 (28)	41,0 (5)	40,6 (5)	40,4 (15)	40,9 (8)
$\gamma_{10,8}$	300,741 (3)	5,12 (18)	5,22 (4)	5,17 (8)	5,11 (8)	5,04 (19)	5,13 (10)
$\gamma_{9,6}$	305,03 (5)	-	-	-	0,023 (3)	0,030 (3)	-
$\gamma_{11,9}$	339,75 (5)	0,234 (16)	-	0,21 (1)	0,21 (3)	0,222 (8)	-
$\gamma_{6,3}$	365,736 (9)	3,327 (117)	3,30 (3)	3,49 (6)	3,46 (6)	3,33 (12)	3,44 (7)
$\gamma_{16,10}$	410,956 (3)	15,25 (53)	15,65 (10)	15,9 (2)	15,5 (4)	15,3 (5)	15,93 (28)
$\gamma_{17,10}$	451,540 (4)	4,02 (15)	3,85 (5)	4,17 (5)	4,04 (11)	4,00 (14)	4,12 (9)
$\gamma_{10,6}$	464,819 (12)	1,651 (61)	-	1,67 (3)	1,73 (7)	1,59 (5)	1,69 (6)
$\gamma_{15,9}$	476,38 (6)	-	-	-	0,052 (6)	0,050 (3)	-
$\gamma_{12,8}$	496,86 (4)	-	-	0,18 (3)	0,17 (1)	0,170 (6)	-
$\gamma_{4,2}$	520,85 (5)	-	-	0,22 (3)	0,21 (1)	0,20 (3)	0,240 (24)1)
$\gamma_{8,3}$	529,825 (4)	13,10 (45)	12,48 (10)	13,3 (2)	13,18 (34)	12,83 (39)	13,46 (26)
$\gamma_{16,9}$	570,995 (5)	7,53 (27)	7,22 (6)	7,65 (9)	7,64 (20)	7,42 (24)	7,81 (15)
$\gamma_{5,2}$	594,536 (24)	0,773 (34)	-	0,77 (2)	0,80 (9)	0,769 (24)	0,80 (4)
$\gamma_{17,9}$	611,620 (17)	1,951 (72)	-	1,86 (4)	1,86 (12)	1,85 (7)	1,95 (11)
$\gamma_{12,7}$	615,84 (9)	-	-	-	0,044 (13)	0,163 (8)	-
$\gamma_{13,7}$	639,97 (9)	0,122 (16)	-	0,12 (1)	0,11 (1)	0,124 (6)	-
$\gamma_{11,6}$	644,689 (15)	0,213 (19)	-	0,19 (1)	0,23 (6)	0,186 (6)	-
$\gamma_{9,3}$	670,526 (4)	7,37 (26)	7,28 (6)	7,53 (9)	7,16 (20)	7,32 (22)	7,60 (14)
$\gamma_{7,2}$	691,304 (12)	1,871 (69)	-	1,87 (4)	1,86 (9)	1,79 (6)	1,84 (5)
$\gamma_{4,1}$	705,09 (7)	-	-	-	0,011 (1)	0,025 (15)	-
$\gamma_{16,8}$	711,697 (3)	74,48 (258)	72,37 (39)	75,7 (8)	75,33 (177)	73,8 (32)	76,4 (14)
$\gamma_{13,5}$	736,70 (7)	0,506 (26)	-	0,51 (2)	0,50 (4)	0,530 (18)	0,547 (23)
$\gamma_{17,8}$	752,280 (4)	16,57 (56)	16,26 (12)	17,0 (2)	17,08 (43)	16,5 (5)	16,98 (33)
$\gamma_{5,1}$	778,827 (6)	4,17 (15)	4,00 (3)	4,25 (6)	4,22 (14)	4,13 (13)	4,27 (8)
$\gamma_{4,0}$	785,81 (7)	-	-	-	0,019 (4)	0,023 (3)	-
$\gamma_{8,2}$	810,286 (4)	78,66 (273)	76,94 (44)	80,1 (8)	79,31 (177)	78,2 (26)	80,3 (12)
$\gamma_{10,3}$	830,565 (4)	13,34 (47)	12,99 (10)	13,5 (2)	13,51 (35)	13,3 (4)	13,62 (26)
$\gamma_{7,1}$	875,663 (7)	0,993 (35)	-	0,99 (4)	1,00 (5)	0,987 (31)	1,002 (25)
$\gamma_{9,2}$	950,988 (4)	3,71 (14)	3,65 (4)	3,89 (6)	3,87 (12)	3,74 (12)	3,85 (8)
$\gamma_{11,3}$	1010,27 (6)	0,096 (8)1)	-	0,11 (1)	0,13 (3)1)	0,107 (4)	-
$\gamma_{14,3}$	1120,35 (5)	0,327 (15)1)	-	0,35 (1)1)	0,28 (5)	0,268 (8)	-
$\gamma_{15,3}$	1146,81 (9)	0,271 (14)	-	0,30 (1)	0,29 (4)	0,279 (9)	0,281 (26)
$\gamma_{16,3}$	1241,519 (4)	1,142 (41)	-	1,21 (4)	1,21 (6)	1,118 (34)	1,12 (4)
$\gamma_{17,3}$	1282,102 (5)	0,246 (13)	-	0,29 (1)	0,28 (4)	0,240 (11)	0,271 (19)
$\gamma_{12,2}$	1306,60 (15)	-	-	-	0,010 (2)	0,0044 (4)	-
$\gamma_{13,2}$	1331,04 (13)	-	-	-	0,010 (1)	0,0051 (6)	-
$\gamma_{14,2}$	1400,79 (2)	0,686 (25)	-	0,74 (2)	0,76 (4)	0,672 (21)	0,720 (27)
$\gamma_{15,2}$	1427,24 (2)	0,667 (25)	-	0,72 (2)	0,77 (4)1)	0,673 (22)	0,708 (21)
-	1446,7 (2)	-	-	-	<0,01	<0,0006	-

Gamma relative emission intensities, references 13 to 17 and the adopted values (18):

$\gamma_{i,f}$	***E_γ* (keV)**	**13**	**14**	**15**	**16**	**17**	**18**
$\gamma_{1,0}$	80,577 (7)	17,00 (22)	16,7 (5)	17;6 (4)	16,050 (120)	17,18 (15)	17,46 (31)
$\gamma_{16,15}$	94,679 (9)	0,208 (10	0,198 (5)	0,23 (3)	-	0,1977 (50)	0,202 (5)
$\gamma_{8,7}$	119,035 (10)	-	0,236 (7)	0,23 (3)	-	0,2384 (72)	0,238 (4)
$\gamma_{16,14}$	121,175 (10)	0,307 (11)	0,326 (9)	0,38 (3)	-	0,343 (9)	0,333 (9)
$\gamma_{17,15}$	135,257 (14)	-	0,1358 (35)	0,15 (3)	-	0,142 (9)	0,1350 (25
$\gamma_{9,8}$	140,702 (20)	-	0,0584 (19)	0,07 (1)	-	0,051 (7)	0,059 (3)
$\gamma_{10,9}$	160,077 (20)	0,153 (7)	0,139 (3)	0,14 (3)	-	0,140 (11)	0,134 (5)
$\gamma_{17,14}$	161,707 (14)	-	0,160 (5)	0,15 (3)	-	0,1580 (80)	0,151 (5)
$\gamma_{2,1}$	184,4107 (11)	100	100	100	100	100	100
$\gamma_{16,13}$	190,747 (16)	-	0,273 (8)$^{1)}$	0,31 (3)	-	0,3010 (62)	0,296 (6)
$\gamma_{16,12}$	214,79 (3)	-	0,671 (17)	0,61 (4)	-	0,600 (10)	0,614 (14)
$\gamma_{8,5}$	215,871 (10)	3,594 (37)	3,60 (9)	3,49 (14)	3,447 (26)	3,566 (85)	3,67 (24)
$\gamma_{17,13}$	231,32 (4)	0,283 (6)	0,260 (7)	0,30 (4)	-	0,2933 (55)	0,302 (8)
$\gamma_{9,7}$	259,70 (3)	1,529 (34)	1,507 (34)	1,45 (5)	1,434 (25)	1,480 (12)	1,487 (9)
$\gamma_{3,2}$	280,468 (7)	41,41 (51)	41,8 (9)	39,8 (9)	40,634 (167)	40,66 (29)	40,75 (21)
$\gamma_{10,8}$	300,741 (3)	5,339 (58)	5,29 (12)	4,98 (13)	5,079 (39)	5,118 (36)	5,15 (4)
$\gamma_{9,6}$	305,03 (5)	-	0,020 (10)	0,023 (3)	-	0,026 (6)	0,0252 (16)
$\gamma_{11,9}$	339,75 (5)	-	0,221 (6)	0,22 (3)	-	0,2250 (36)	0,2229 (27)
$\gamma_{6,3}$	365,736 (9)	3,589 (45)	3,51 (9)	3,34 (9)	3,439 (47)	3,404 (24)	3,39 (4)
$\gamma_{16,10}$	410,956 (3)	16,49 (19)	16,02 (36)	15,0 (4)	15,424 (74)	15,81 (11)	15,65 (22)
$\gamma_{17,10}$	451,540 (4)	4,235 (60)	4,11 (10)	3,89 (13)	4,023 (30)	4,062 (42)	4,02 (5)
$\gamma_{10,6}$	464,819 (12)	1,729 (35)	1,73 (4)	1,66 (7)	2,027 (31)	1,665 (19)	1,73 (6)
$\gamma_{15,9}$	476,38 (6)	-	0,0494 (26)	0,052 (7)	-	-	0,0500 (18)
$\gamma_{12,8}$	496,86 (4)	-	0,175 (4)	0,17 (3)	-	0,174 (16)	0,173 (4)
$\gamma_{4,2}$	520,85 (5)	-	0,276 (14)$^{1)}$	0,21 (3)	-	0,212 (13)	0,211 (8)
$\gamma_{8,3}$	529,825 (4)	13,19 (15)	-	12,6 (4)	13,380 (126)	13,33 (10)	13,0 (6)
$\gamma_{16,9}$	570,995 (5)	7,964 (91)	-	7,27 (23)	7,505 (71)	7,71 (6)	7,49 (27)
$\gamma_{5,2}$	594,536 (24)	0,761 (22)	-	0,78 (7)	-	0,880 (20)	0,80 (8)
$\gamma_{17,9}$	611,620 (17)	2,097 (26)	-	1,86 (11)	1,952 (60)	1,911 (36)	1,81 (29)
$\gamma_{12,7}$	615,84 (9)	-	0,138 (11)	0,044 (13)	-	0,160 (10)	0,13 (4)
$\gamma_{13,7}$	639,97 (9)	-	0,137 (4)	0,11 (2)	-	0,138 (9)	0,130 (4)
$\gamma_{11,6}$	644,689 (15)	-	0,206 (5)	0,21 (4)	-	0,189 (12)	0,198 (5)
$\gamma_{9,3}$	670,526 (4)	7,718 (84)	-	6,98 (22)	7,618 (45)	7,56 (6)	7,36 (28)
$\gamma_{7,2}$	691,304 (12)	1,872 (40)	-	1,78 (9)	1,914 (17)	1,862 (21)	1,82 (10)
$\gamma_{4,1}$	705,09 (7)	-	0,0272 (7)	0,011 (2)	-	-	0,019 (9)
$\gamma_{16,8}$	711,697 (3)	77,51 (62)	-	72,0 (19)	76,30 (35)	76,3 (6)	75,7 (16)
$\gamma_{13,5}$	736,70 (7)	0,510 (12)	-	0,49 (4)	-	0,524 (16)	0,514 (7)
$\gamma_{17,8}$	752,280 (4)	17,16 (14)	-	16,2 (5)	16,973 (84)	16,98 (12)	16,8 (4)
$\gamma_{5,1}$	778,827 (6)	4,279 (56)	-	4,04 (14)	4,257 (28)	4,242 (33)	4,15 (11)
$\gamma_{4,0}$	785,81 (7)	-	0,0312 (11)	0,019 (4)	-	-	0,026 (5)
$\gamma_{8,2}$	810,286 (4)	80,81 (59)	-	76,1 (20)	80,52 (38)	80,3 (6)	79,1 (14)
$\gamma_{10,3}$	830,565 (4)	13,87 (18)	-	12,9 (4)	13,639 (79)	13,64 (10)	13,41 (23)
$\gamma_{7,1}$	875,663 (7)	1,003 (21)	-	0,97 (6)	-	0,501 (9)$^{1)}$	0,994 (11)
$\gamma_{9,2}$	950,988 (4)	3,898 (48)	-	3,68 (12)	3,789 (25)	3,793 (30)	3,785 (21)
$\gamma_{11,3}$	1010,27 (6)	-	0,1113 (28)	0,11 (2)	-	0,107 (6)	0,1095 (21)
$\gamma_{14,3}$	1120,35 (5)	-	0,281 (8)	0,28 (3)	-	0,278 (10)	0,275 (5)
$\gamma_{15,3}$	1146,81 (9)	0,290 (6)	0,289 (8)	0,27 (3)	-	0,279 (6)	0,284 (3)
$\gamma_{16,3}$	1241,519 (4)	1,211 (10)	-	1,14 (5)	-	1,121 (14)	1,17 (4)
$\gamma_{17,3}$	1282,102 (5)	0,268 (12)	0,263 (7)	0,27 (3)	-	0,2434 (30)	0,252 (9)
$\gamma_{12,2}$	1306,60 (15)	-	0,00610 (3)	0,010 (2)	-	-	0,0076 (15)
$\gamma_{13,2}$	1331,04 (13)	-	0,0025 (10)	0,010 (2)	-	-	0,0059 (16)
$\gamma_{14,2}$	1400,79 (2)	0,707 (17)	-	0,70 (3)	-	0,689 (7)	0,700 (7)
$\gamma_{15,2}$	1427,24 (2)	0,705 (28)	-	0,68 (3)	-	0,696 (12)	0,687 (7)
$\gamma_{15,2}$	1427,24 (2)	-	-		<0,01	-	-

1) Outlier
2) 214, 8 + 215, 8 keV doublet
Upper limits for a possible 1446,7 keV transition have been determined by authors 10, 11, 16.

1 Burson et al. 1967
2 Gunther and Parsignault 1967
3 Reich and Cline 1970
4 Lavi 1973
5 Lingeman et al. 1974
6 Gehrke et al. 1977
7 Sampson 1978
8 Blagojevic and Wood 1982
9 Sooch et al. 1982
10 Ogandaga et al. 1986
11 Adam et al. 1988 (give also values for six additional very weak transitions)
12 Danilenko et al. 1989
13 Wang Xin Lin 1992
14 Wagner 1992 (gives additionally four weak transitions)
15 Ardisson 1992
16 Miyahara et al. 1994
17 Morel et al. 1996
18 Adopted value

The final values of Hino et al. (2000) were not available when this evaluation was carried out.
The absolute emission probabilities (Table 4.2) are calculated by multiplying the relative values by the normalization factor f_N = 0,725 (3).
The transition probabilities (Table 2.2) are calculated by multiplying the emission probabilities by $(1 + \alpha_t)$.

5 Main Production Mode

Taken from Firestone (1996).

6 References

References are given only in those cases where the reference is not already included in the list of references in the data tables.

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