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Activation Product Decay Data: UKPADD6.8

Report to Nexia Solutions Ltd & UK Atomic Energy Authority

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Executive Summary

The latest version of the UK Activation Product Decay Data Library (UKPADD6.8) is described in this report, as assembled for general use in March 2008.

The decay data of various radionuclides have been evaluated on the basis of a series of well-defined specifications derived from the requirements of the UK nuclear power, fuel reprocessing and waste management programmes. These radionuclides are primarily activation products that are of immediate relevance to the European Fusion Programme and to the operation and decommissioning/disposal of fission-based reactor facilities, along with various standards that are commonly used to calibrate gamma-ray spectrometers. Over more recent years, decay scheme data for a number of fission products have also been evaluated and included in UKPADD on request because of their known inadequacies in other equivalent databases. Recommended data include half-lives, branching fractions, alpha, beta and gamma-ray energies and emission probabilities, total decay energies, mean alpha, beta and gamma energies, internal conversion coefficients, and all associated uncertainties. Computer-based files have been generated in ENDF-6 format, including lists of the references used to produce the proposed decay schemes and comments that identify any observed inadequacies.

All evaluations for UKPADD6.8 were carried out by Dr A L Nichols[1].

The previous version of the library, UKPADD6.7, was released in March 2007. This library had been assembled over a number of years and the structure of many of the older files no longer conformed to modern standards, causing difficulties in the assimilation of data from UKPADD into the JEFF-3 decay data file. Thus, all data sets within UKPADD6.8 have been updated to bring them up to the required standard and to facilitate the adoption of the data into JEFF-3 and future libraries. This work was sponsored by the UK Nuclear Decommissioning Authority through Nexia Solutions Ltd.

Data for 23 nuclides have been newly evaluated or re-evaluated in UKPADD6.8 during the course of 2007/08. These evaluations were sponsored by the UK Atomic Energy Authority in support of the European Fusion Programme.

Historically, the evaluation work and assembly of the files has been funded by BNFL plc, Sellafield, and the UK Department of Trade and Industry and Euratom (UK Atomic Energy Authority/Euratom Fusion Association). Production of this report was funded by the UK Nuclear Decommissioning Authority through Nexia Solutions Ltd and by the UK Atomic Energy Authority.

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Contents

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1 Introduction

The UK Activation Product Decay Data Library was first released in 1977 as UKPADD1 (1). Improvements in the available decay data through various spectroscopic measurements led to a comprehensive evaluation of the decay data for 236 radionuclides. These improved data were released as UKPADD2 in 1993 (2). A significant fraction of the UKPADD2 decay-data library was incorporated into version 2 of the Joint Evaluated File JEF-2.2 (3). Subsequent reviews of JEF-2.2 data highlighted the need for further developments in the recommended data for fission and fusion applications. Hence, UKPADD6 was developed and released in 1999 (4).

A continuing programme of decay data evaluation has been underway with the aim of producing and maintaining the recommended libraries of relevant nuclear data. This long-term initiative has led to significant improvements and extensions of the UKPADD library. Since the beginning of 1999, the evaluation programme has been sponsored primarily by the UK Atomic Energy Authority in support of the European Fusion Programme. Specific nuclides requiring improved decay data have been identified by R A Forrest (UKAEA) and A L Nichols (5). Over the period from 1999 to 2007, a further 131 radionuclides were newly evaluated or re-evaluated, and details of these evaluations were published in a series of UK Nuclear Science Forum papers (6,7,8,9,10,11). All evaluations were carried out by A L Nichols. UKPADD libraries are made available to the international community via the NEA Data Bank, and new evaluations are also submitted for possible inclusion in the JEFF-3 decay data library.

The most recent version of the UKPADD library (UKPADD6.8), released in March 2008, is described in this paper. This latest library contains evaluations for 573 radionuclides.

The previous version of the library was released in February 2007 as UKPADD6.7 (12). This library had been assembled over a number of years and the structure of many of the older files no longer conformed to modern standards, causing difficulties in the assimilation of data from UKPADD into the JEFF3.1.1 decay data file (13). Thus, all data sets have been re-visited and updated for UKPADD6.8 to bring them to the required standard and to facilitate the adoption of the data into JEFF-3 and future libraries. This work was sponsored by the UK Nuclear Decommissioning Authority through Nexia Solutions Ltd.

Data for 23 nuclides have been newly evaluated or re-evaluated in preparation for the release of UKPADD6.8. These evaluations were carried out by Dr A L Nichols and sponsored by the UK Atomic Energy Authority in support of the European Fusion Programme.

The evaluation procedure and contents of UKPADD6.8 are summarized in the following sections.

2 Decay Data

UKPADD6.8 contains recommended data for the following parameters (see also Section 4):

(i) half-lives,

(ii) total decay energies (Q-values),

(iii) branching fractions,

(iv) alpha-particle energies and emission probabilities,

(v) beta-particle energies, emission probabilities and transition types,

(vi) gamma-ray energies, emission probabilities and internal-conversion coefficients,

(vii) neutron energies and emission probabilities,

(viii) spontaneous fission data including prompt gamma-ray spectra.

The spin and parity of the decaying nuclide have been defined, and uncertainties are assigned to all evaluated data. Other data in UKPADD6.8 (mean energies, discrete electrons and mean X rays) were derived from the above data by using the processing code COGEND (14). The component contributions to the average energies (light particle, electromagnetic and heavy particle) are derived from the evaluated input data by COGEND. The code also contains data libraries of fluorescence yields, Auger-electron energies, mean x-ray energies and electron-wave-function ratios from which capture ratios can be calculated.

The library has been generated in ENDF-6 format (15). There is a general information section for each nuclide which contains:

(i) name of the evaluator and date of the evaluation (month and year),

(ii) list of references used to construct the recommended data set,

(iii) detailed comments associated with the evaluation,

(iv) consistency check of the evaluated data.

The recommended decay data are contained within the main data section. Every effort has been made to produce consistent and comprehensive data sets. When necessary, theoretical internal conversion coefficients have been used in conjunction with the evaluated gamma-ray data. X-ray data were derived from the energy and emission probability data held within COGEND (16, 17).

All of the energy data are in eV, and the absolute emission probabilities are expressed as fractions of the decay (calculated from the spectral normalisation factor and relative emission probabilities). The data in UKPADD6.8 are listed as described in Reference 15, and summaries of the contents of the updated library are given in Tables 1 and 2.

The consistency of the recommended data has been determined by calculating the percentage deviation between the effective Q-value and the calculated Q-value:

$$\text{effective Q-value} = \sum_{i=1}^{\text{all BF}} Q_i . BF_i \qquad (1)$$

where Q_i and BF_i are the Q-value and branching faction of the i^{th} decay mode (i.e. weighted sum of the evaluated Q-values of the radionuclide),

$$\text{calculated Q-value} = \sum_{i}^{\text{all } \alpha} E_{\alpha_i} P_{\alpha_i} + \sum_{j}^{\text{all } \beta} E_{\beta_j} P_{\beta_j} + \sum_{k}^{\text{all } \gamma} E_{\gamma_k} P_{\gamma_k} + \sum_{l}^{\text{all x-rays}} E_{x_l} P_{x_l} + \text{etc.} \qquad (2)$$

where $E_{\alpha_i}, E_{\beta_j}, E_{\gamma_k}, E_{x_l}$, etc., and $P_{\alpha_i}, P_{\beta_j}, P_{\gamma_k}, P_{x_l}$, etc.

are the energies and emission probabilities of the i^{th} alpha particle, j^{th} beta particle, k^{th} gamma ray, l^{th} x ray, etc. of the individual decay process.

The percentage deviations of the data in the UKPADD6.8 library are given in Table 1. Percentage deviations above 5% would be regarded as high and imply a poorly defined decay scheme; a value of less than 5% indicates the construction of a reasonably consistent decay scheme.

3 Evaluation Procedure

3.1 Overview

An initial decay scheme was constructed for each radionuclide from a suitable combination of the various data sources. The evaluation procedure was as follows:

(i) assess the status of the existing data,

(ii) identify data discrepancies,

(iii) evaluate and recommend decay data.

The emission probabilities have been expressed as the absolute probability of the transition (α, β, conversion electron, X-ray or γ ray) per decay. All available measurements were generally taken into account during an evaluation, including experimental data from laboratory reports and written private communications. Comprehensive statements of the precise evaluation procedure were prepared after each assessment, as well as details of any changes made to the reported data. Under specific circumstances, the evaluations involved the determination of a weighted mean for each parameter. No individual measurement was allowed to contribute more than 50% to the sum of weights when more than one value of the same parameter was reported, and the uncertainty of the datum was increased if necessary. If the set of accepted experimental data proved to be inconsistent, one of several possibilities was adopted:

(i) recommend the unweighted mean,

(ii) reject some measured values on the basis of objective or subjective judgements (e.g. inappropriate calibration procedure or ill-defined measurement techniques employed by the metrologist),

(iii) change the weights.

An appropriate method of changing weights was preferred rather than outright rejection of data. Any serious problems encountered during an evaluation are described in the Comments Section associated with each nuclide in the library. If the resulting decay scheme has any outstanding problems, a statement was made to the effect that better measurements are required.

3.2 Procedures and Consistency Checks

The following procedures and consistency checks form the basis of the evaluation strategy used to update and improve the UKPADD library.

(i) Every effort was made to ensure that there was a reasonable emission-probability balance between the population and de-population of all excited levels in the decay scheme.

(ii) All decay modes of each radioactive nuclide were completely specified in terms of both the branching ratios and the Q-values. The Q-value, defined as the energy difference between the initial and final states, takes account of the energies of any metastable states which are involved in the decay.

(iii) The sum of all α, β^-, β^+/electron-capture and isomeric gamma-emission probabilities were consistent with the corresponding branching fractions.

(iv) Gamma-ray emission probabilities must be the photon probabilities per disintegration and were listed as percentages in the data files. This means that relative photon probabilities were normalised in a consistent manner.

(v) Internal-conversion coefficients for gamma-ray transitions were consistent with both the photon and total transition probabilities,
i.e. (photon + conversion electron) emission probabilities = total transition probability.

(vi) When the internal conversion of a gamma-ray transition was significant, theoretical internal-conversion coefficients were adopted if experimental data were unavailable. This ensured that the transition energy was appropriately shared between the electromagnetic and electron components.

(vii) The nature of the beta transition was taken into account in the calculation of mean beta energies from the evaluated end points. This information was inferred from the spin and parity assignments proposed for the levels involved.

(viii) Energies and emission probabilities of conversion electrons, Auger electrons, X rays and annihilation radiation were derived in a consistent manner.

(ix) Uncertainties were estimated for all of the parameters incorporated into UKPADD6.

(x) Each evaluation was fully documented. The evaluated ENDF-6 files include a descriptive section that includes comments on inconsistencies and any assumptions made by the evaluator to deal with such problems.

3.3 Production Procedure

(i) The evaluation is undertaken and the initial input data are prepared by the evaluator.

(ii) The evaluation is converted into a form suitable for input to COGEND.

(iii) The COGEND input data are checked against the original evaluation.

(iv) The COGEND code is run and the input file and ENDF-6 output file are sent to the evaluator for checking.

(v) Any corrections and improvements are defined by the evaluator, and COGEND is rerun until he/she is satisfied with the results.

COGEND generates an ENDF-6 format file. The computer codes STANEF (18), CHECKR (18) and FIZCON (19) are applied to the file. Any diagnostic reports from these codes are reported to the evaluator who directs any further changes necessary.

4 Activation Product Decay Data Library, UKPADD6.8

4.1 Changes Since the Last Release

4.1.1 Updates to File Structure

A number of changes have been made for this release of the library to ensure that the structure of the evaluated files conforms to modern standards and to facilitate the assimilation of the data into JEFF-3 and future libraries.

The main tool used to re-structure the files was the ENDF-6 utility code STANEF7.02 (18). Using the default options, this code performs the following actions:

sets the chemical symbol to mixed case, e.g. Ce,

reconstructs the file directory to ensure consistency with the evaluated data,

converts numeric fields to the standard ENDF-6 form.

These changes were applied to all nuclides in UKPADD6.8. Furthermore, a number of other changes were applied to selected nuclides, as outlined below.

The second field of the third record of the General Information section of an ENDF-6 format file contains the parameter EMAX (15), the maximum energy for the evaluation. This parameter has no meaning for decay data files and should be set to zero. However, EMAX had been set to 20 MeV for 49 nuclides in UKPADD6.7, and therefore EMAX values for these nuclides were re-set to zero.

The ENDF-6 material (MAT) number used for 17 of the nuclides was no longer consistent with the value expected by the latest version of the ENDF-6 format checking code, CHECKR7.02 (18). MAT numbers for these nuclides were altered to the values expected by CHECKR7.02, thus ensuring a consistent set of MAT numbers has been adopted for all nuclides.

A non-ASCII character in the Comments Section of Y-97 was removed.

4.1.2 New Evaluations

The European Fusion Programme requires improved decay data files for specific nuclides. Inadequate decay data files have been identified by R A Forrest (UKAEA Fusion, Culham Laboratory), on the basis of their relative activities and gamma-dose rates as a function of time (20). Over 750 radionuclides were assessed, and a set of 338 nuclides were recommended for new measurements and re-evaluation with various degrees of priority.

Twenty-three of these nuclides were evaluated during 2007/08 (Table 3), and decay data prepared in ENDF-6 format. One aim was to improve the quality of these particular decay data files, and so enhance the credibility of the UKPADD and JEFF-3 databases for nuclear applications.

The resulting quality of the recommended decay data was based on the subjective judgement of the evaluator and a well-defined consistency check of the proposed data set, as outlined in the Comments Sections of the files. All such extensive comments have been assembled in Appendix 1 for each evaluation, and cite a significant number of specific references by first-named author. However, these references are not listed in this report as they are too numerous for such an exercise, and the reader is referred to the Comments Section of the relevant ENDF-6 decay-data file of the radionuclide for full details.

Overall, the recommended decay data exhibit good to excellent consistency when Q-values and branching fraction data are compared with the discrete emission data (i.e., gamma rays, X-rays, Auger and conversion electrons, and EC and beta-particle transitions; see Table 1).

4.1.3 Consistency Checks

All the files within UKPADD6.8 were checked using CHECKR7.02 and FIZCON (19).

Six nuclides produced a warning stating when processed through CHECKR that the material number (MAT) was inconsistent with the ZA number (Cs-123, Cs-123m, Tb-146, Tb-146m, Tl-193 and Tl-193m). This warning arose because the MAT numbers for these nuclides exceed the standard ENDF-6 numbering scheme. For example, the first stable isotope of Tl is Tl-203 which is assigned the MAT number 8125. The MAT number for Tl-193 is 3*10 less than this value, i.e. 8095. Thus the first two digits do not match the Z number and produce the warning message from CHECKR.

FIZCON produced diagnostic messages for a number of nuclides, as described below.

elis not in range 0.00000E+00 to 0.00000E+00

This message is present for all metastable nuclides. The parameter ELIS is the excitation energy (15), and is non-zero for metastable nuclides. FIZCON checks that this parameter is between zero and EMAX, the upper energy of the evaluation. EMAX is zero for decay data files, and therefore the message does not apply to decay data files and can be ignored.

ft value too small

This message occurred for Mg-28, Rb-93, Y-97m, Rh-104, Ag-115m, Cd-107, I-138, Ho-160, Ta-177, Os-180, Ir-190, Hg-190 and Pb-201. FIZCON checks that the ft value for beta transitions is within certain limits dependent on the transition type. Although beta transitions that fail this test had been individually assessed at the time of evaluation, the evaluator believed that this condition could not be averted.

total energy release sumup failure

Evaluations have been derived theoretically for 35 fission products important at short cooling times in decay-heat calculations (see Section 4.2). The theoretical spectra are given only in continuum form, resulting in the associated antineutrino energy not being included in the files except as part of the Q value for the decay mode. This causes the total energy sum-up test to fail. There is no practicable way to prevent this process happening, and FIZCON prints the following message.

```
warning: continuum spectrum for beta-radiation.
         fizcon cannot calculate antineutrino energy
         for total energy release.
```

Two additional nuclides also failed the total energy sum-up test (In-116 and Po-208), although the discrepancy is rather small for Po-208 (-0.0380%). The reasons for these two failures are not clear.

gamma ray needed, source mode= 4

This message was present for Li-8 and indicates that the discrete energy of the single alpha particle (plus recoil) is less than the Q value for the decay mode and thus an associated gamma emission is expected. As there are no gamma data present, the warning is issued.

Various messages relating to energy sum-up discrepancies were also obtained for the incomplete evaluations of Cs-136m, Pm-155 and Ho-163. Further details of these evaluations are given in Section 4.2 below.

4.2 Contents of the Library

The UKPADD6.8 evaluated decay data library has been assembled in the internationally-accepted ENDF-6 format adopted for nuclear applications, as described in Reference 15. Comprehensive decay scheme data are presented for 573 radionuclides.

A General Information/Descriptive Data Section is defined for each nuclide (MF=1, MT=451) that contains the following information:

(i) radionuclide, date of evaluation, name of evaluator, date of distribution (month, year) and most recent date of issue (year, month and day);

(ii) library name (UKPADD6.8), file identifier (material number), data type (radioactive decay data) and format type (ENDF-6);

(iii) list of references used to determine the recommended data set;

(iv) detailed comments concerning the evaluation;

(v) specific decay data not contained in the main decay data section, including beta-particle transition parameters;

(vi) consistency check of the recommended data set.

The recommended decay data are contained within the primary data section (MF=8, MT=457). These data are:

(i) spin and parity of the decaying radionuclide;

(ii) half-life;

(iii) average energy per disintegration for three general radiation types (light particles, electromagnetic radiations and heavy particles), followed by the individual components of these types for evaluations since September 2002;

(iv) decay modes, Q-values and branching fractions;

(v) radiation decay data, including gamma-ray, beta-particle, electron-capture, alpha-particle, neutron, discrete electron and x-ray transitions;

(vi) spontaneous fission decay data.

The decay parameters of the majority of radionuclides in UKPADD6.8 have been reasonably well defined in the published literature, and were evaluated with good precision and confidence to produce consistent decay schemes.

Various decay parameters and continuum spectra have been theoretically derived for 35 neutron-rich nuclides deemed to be important at short cooling times in decay-heat calculations (denoted by # in Table 1). While each of these fission products contributes significantly to the decay heat of irradiated fuel (> 0.01 of the fractional cumulative yield), they have proved extremely difficult (if not impossible) to prepare, isolate and study experimentally. The US ENDF/B-VI decay-data library contains files of theoretical data for 33 of these nuclides (21), and they were considered as possible candidates for incorporation into UKPADD, with supportive data from Takahashi *et al.* (22) and Audi *et al.* (23). Furthermore, the relevant data for nine other radionuclides proved insufficient to evaluate and recommend complete decay schemes at the time of their evaluation. These nine troublesome radionuclides are discussed in more detail below - references associated with these particular comments are not defined in the reference list of this report, but can be found in the original database.

He-8
He-8 undergoes beta-particle and neutron decay. While a reasonably consistent decay scheme can be assembled, the neutron emissions are less well defined and constitute an incomplete decay scheme.

Li-9
Li-9 undergoes beta-particle and neutron decay. The latter emissions are relatively complex and poorly characterised, resulting in the formulation of an incomplete decay scheme.

V-54
There are major difficulties in defining the population-depopulation transitions of the 834.8- and 3159.3-keV nuclear levels. Furthermore, it is assumed that no beta transitions occur to the nuclear levels at 834.8, 3159.3, 3222.2 and 3436.8 keV, despite contrary evidence from gamma-ray measurements.

Sb-129m
A significant number of gamma-ray transitions can not be satisfactorily incorporated into the proposed decay scheme, and the calculated normalisation factor for the gamma rays is judged to be a poor estimate.

Cs-136m
Cs-136m has only been detected from an analysis of Cs X-rays following the proton irradiation of lanthanum. No decay data have been reported, although this metastable level at 600 keV has been postulated on the basis of the equivalent observed decay of I-136m. A decay scheme can not be proposed with such a lack of information.

Pm-155
A complete and consistent decay scheme can not be sensibly derived from the detailed TAGS (total absorption gamma-ray spectrometry) studies of Greenwood *et al*. (1997) because of the significant lack of discrete gamma-ray and gamma-gamma coincidence measurements reported in the open literature. While the TAGS spectrum indicates the existence and population of at least 37 nuclear levels of Sm-155, only five gamma-ray emissions have been characterised (by Greenwood *et al*., 1982). Unpublished gamma-ray studies at the University of Idaho and INEL have been mentioned in relatively vague terms, and good agreement was claimed between these unreported measurements and the simulated spectra (through TAGS) up to a nuclear level energy of 1362.1 keV. Sixteen additional “pseudolevels” were also postulated by Greenwood *et al*. (1997) in order to explain the TAGS spectrum.

There are a very large number of uncertainties associated with the decay of Pm-155, and extensive gamma-ray studies are required to assist greatly in the evolution of a comprehensive and consistent decay scheme. Many features of the decay scheme need to be explored and clarified (particularly the emission probabilities of all the gamma rays, and the beta-particle energies and emission probabilities).

Ho-163
Ho-163 undergoes electron capture decay through the M and higher shells (N, O, etc.). The models in COGEND and the checking code FIZCON assume that this form of decay will involve capture from the innermost K and L shells. Hence, ENDF-6 data can not be generated using COGEND, nor checked by FIZCON. Fractional atomic shell electron capture probabilities calculated using the EC-CAPTURE code yield: P(K) = 0.0, P(L) = 0.0, P(M) = 0.1967, P(N) = 0.6688 and P(O) = 0.1346 for the 2.650-keV decay to the ground state of Dy-163. Auger and X-ray data need to be determined separately.

Au-198m
The significant 333-keV gamma ray observed in the decay of Au-198m can not be satisfactorily placed in the proposed decay scheme. There is also a lack of gamma-ray data to produce a satisfactory decay scheme.

Tl-201
There are difficulties in defining the emission probabilities and (M1+E2) mixing ratios of the low-energy 1.56- and 5.87-keV gamma rays, and there are significant uncertainties in these data. The emission probabilities of these low-energy transitions were derived from the various assumptions based on population/de-population of the relevant nuclear levels, an estimated emission probability for the 26.28-keV gamma ray, and zero EC decay to the 26.28-keV nuclear level and ground state of Hg-201. The nature of the low-energy gamma-ray emissions and their high internal conversion prevented confident recommendations for a number of the transitions in the Tl-201 decay scheme.

There are 573 full evaluations in UKPADD6.8, of which 35 files are assembled from theoretical data and 9 are defined as being incomplete data sets. The remaining 529 radionuclides have been evaluated to give reasonably consistent decay schemes. All of the data files are judged to be suitable for a wide range of applications in the nuclear industry and for research purposes.

5 Conclusions

Sets of recommended decay scheme and emission probability data have been derived for a series of radionuclides identified predominantly as activation products and calibrants. The resulting evaluated data sets represent significant improvements in the quality of the derived decay parameters.

Data for 23 nuclides have been newly evaluated or re-evaluated and exhibit good to excellent consistency. A significant number of radionuclides remain to be evaluated in greater detail as documented by Forrest (20), and one intention should be to continue this work in order to bring this evaluation programme to a satisfactory conclusion.

All of the evaluated decay data have been assembled with other files from previous versions of UKPADD to create the UKPADD6.8 library in ENDF-6 format (573 radionuclides, as listed in Table 1). Rigorous consistency checks have been undertaken to confirm the validity and completeness of the data before releasing the updated library. Comprehensive details of each evaluation can be found within the Comments Section of individual ENDF-6 files.

The structure of all the evaluated files has been updated to ensure the files are consistent with modern standards and can be assimilated into JEFF-3 and future libraries. UKPADD6.8 is available via the NEA Data Bank, and all the decay data comprising UKPADD6.8 have been submitted for possible inclusion in the JEFF-3 Decay Data Library.

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Table 1. Decay Data Summary

Nuclide	Evaluation Date	$T_{1/2}$	Decay Modes	Q % Deviation
1-H - 3	OCT82	12.330y	β–	0.0000
2-He- 6	OCT82	0.808s	β–	0.0000
2-He- 8	FEB03	0.122s	β– (0.88), β–n (0.12)	Incomplete
3-Li- 8	APR92	0.838s	β–α	0.0419
3-Li- 9	APR92	0.178s	β– (0.505), β–n (0.495)	Incomplete
4-Be- 7	OCT82	53.240d	EC	0.0111
4-Be- 8	APR92	7.00000E-17s	α	-0.0092
4-Be- 10	OCT82	1.60004E+06y	β–	0.0000
4-Be- 11	DEC90	13.810s	β– (0.97), β–α (0.03)	0.0915
5-B - 12	OCT82	0.020s	β– (0.9842), β–α (0.0158)	0.0002
5-B - 13	FEB03	0.017s	β– (0.99724), β–n (0.00276)	0.0244
6-C - 14	OCT82	5.73012E+03y	β–	0.0000
6-C - 15	OCT82	2.449s	β–	-0.0733
7-N - 13	DEC94	9.965m	EC	0.0000
7-N - 16	JAN02	7.130s	β– (0.9999880), β–α (1.2000E-05)	0.0577
7-N - 17	JAN02	4.170s	β– (0.05), β–n (0.9499750), β–α (2.5000E-05)	0.0700
8-O - 19	OCT82	26.910s	β–	-0.1655
9-F - 18	DEC94	1.828h	EC	0.0000
9-F - 20	OCT82	11.030s	β–	0.0051
9-F - 21	OCT05	4.158s	β–	0.0666
10-Ne- 23	OCT82	37.200s	β–	0.0183
11-Na- 22	OCT92	2.603y	EC	0.0018
11-Na- 24	OCT92	14.965h	β–	0.0068
11-Na- 24m	NOV82	0.020s	β– (0.005), IT (0.995)	0.0003
11-Na- 25	OCT82	59.600s	β–	0.1602
11-Na- 26	NOV82	1.080s	β–	-0.0077
12-Mg- 27	NOV82	9.458m	β–	0.0001
12-Mg- 28	NOV82	20.9h	β–	0.1597
13-Al- 26	NOV82	7.20016E+05y	EC	0.0250
13-Al- 26m	DEC94	6.345s	EC	0.0000
13-Al- 28	NOV82	2.241m	β–	0.0022
13-Al- 29	NOV82	6.560m	β–	-0.0207
13-Al- 30	NOV82	3.650s	β–	-0.0638
14-Si- 31	NOV82	2.620h	β–	-0.0014
14-Si- 32	NOV82	330.007y	β–	0.0000
15-P - 32	NOV82	14.270d	β–	0.0000
15-P - 33	NOV82	25.4d	β–	0.0000
15-P - 34	DEC94	12.4s	β–	-0.0062
16-S - 35	NOV82	87.5d	β–	0.0000
16-S - 37	NOV82	4.990m	β–	-0.0801
17-Cl- 34	DEC94	1.526s	EC	0.0000
17-Cl- 34m	DEC94	32.1m	EC (0.52), IT (0.48)	-0.0474
17-Cl- 36	SEP01	3.07006E+05y	β– (0.981), EC (0.019)	0.0001
17-Cl- 38	DEC82	37.2m	β–	-0.0079
17-Cl- 38m	NOV82	0.715s	IT	-0.0640
17-Cl- 39	OCT05	55.6m	β–	-0.0153
18-Ar- 37	DEC82	35.040d	EC	-0.0007
18-Ar- 39	DEC82	269.006y	β–	0.0000

Nuclide	Evaluation Date	$T_{1/2}$	Decay Modes	Q % Deviation
18-Ar- 41	JAN83	1.827h	β–	-0.0384
18-Ar- 42	DEC82	33.001y	β–	0.0000
19-K - 38	DEC94	7.610m	EC	0.0013
19-K - 38m	DEC94	0.924s	EC	0.0000
19-K - 40	DEC82	1.28003E+09y	β– (0.893), EC (0.107)	-0.0011
19-K - 42	FEB83	12.370h	β–	0.0066
19-K - 43	DEC82	22.2h	β–	-0.0474
19-K - 44	MAR90	22.130m	β–	0.1283
20-Ca- 41	DEC82	1.03002E+05y	EC	0.0035
20-Ca- 45	JAN92	162.7d	β–	0.0000
20-Ca- 47	APR92	4.538d	β–	0.1213
20-Ca- 49	DEC82	8.720m	β–	-0.0229
21-Sc- 44	JAN83	3.927h	EC	0.0171
21-Sc- 44m	JAN83	2.442d	EC (0.0123), IT (0.9877)	0.0391
21-Sc- 45m	NOV07	0.325s	IT	-0.0903
21-Sc- 46	OCT92	83.790d	β–	-0.0028
21-Sc- 46m	FEB83	18.7s	IT	0.4710
21-Sc- 47	DEC91	3.346d	β–	0.0017
21-Sc- 48	FEB83	1.820d	β–	0.0226
21-Sc- 49	DEC82	57.2m	β–	0.0000
21-Sc- 50	JAN92	1.708m	β–	-0.0075
21-Sc- 50m	JAN92	0.350s	β– (0.0125), IT (0.9875)	-0.0276
22-Ti- 45	APR92	3.080h	EC	0.0022
22-Ti- 51	JAN92	5.8m	β–	0.0073
23-V - 48	FEB83	15.974d	EC	-0.2125
23-V - 49	FEB83	330.0d	EC	0.0029
23-V - 52	JAN92	3.745m	β–	-0.0006
23-V - 53	APR92	1.620m	β–	-0.2563
23-V - 54	APR92	49.8s	β–	Incomplete
24-Cr- 49	JAN83	41.9m	EC	-0.0171
24-Cr- 51	AUG89	27.706d	EC	0.0053
24-Cr- 55	FEB92	3.540m	β–	0.0000
25-Mn- 53	NOV93	3.68008E+06y	EC	0.0042
25-Mn- 54	DEC91	312.3d	EC	-0.0001
25-Mn- 56	JAN92	2.579h	β–	-0.0179
25-Mn- 58	APR97	1.087m	β–	-0.3450
25-Mn- 58m	APR97	2.7s	β–	0.1037
26-Fe- 53	JAN92	8.510m	EC	-0.2021
26-Fe- 53m	JAN92	2.580m	IT	0.1882
26-Fe- 55	JAN92	2.735y	EC	-0.0020
26-Fe- 59	DEC91	44.502d	β–	-0.0172
26-Fe- 60	JAN94	1.50003E+06y	β–	0.0000
26-Fe- 63	DEC00	6.1s	β–	0.0119
27-Co- 55	FEB92	17.530h	EC	0.0305
27-Co- 56	APR92	77.260d	EC	0.5072
27-Co- 57	JAN92	271.790d	EC	0.0020
27-Co- 58	JUL91	70.860d	EC	-0.0023
27-Co- 58m	JUL91	8.940h	IT	-0.3171
27-Co- 60	DEC91	5.272y	β–	0.0053
27-Co- 60m	JAN94	10.470m	β– (0.0025), IT (0.9975)	0.0838
28-Ni- 57	JAN92	1.487d	EC	-0.0314
28-Ni- 59	DEC91	7.60017E+04y	EC	-0.0056

Nuclide	Evaluation Date	$T_{1/2}$	Decay Modes	Q % Deviation
28-Ni- 63	JUL90	99.002y	β–	0.0000
28-Ni- 65	DEC91	2.520h	β–	0.0352
28-Ni- 66	AUG93	2.267d	β–	0.0000
28-Ni- 67	JUL01	21.0s	β–	0.0093
29-Cu- 62	FEB92	9.750m	EC	0.0001
29-Cu- 64	JAN92	12.702h	β– (0.3886), EC (0.6114)	-0.0007
29-Cu- 66	JAN92	5.1m	β–	0.0166
29-Cu- 67	AUG93	2.579d	β–	0.0171
30-Zn- 63	MAR91	38.4m	EC	0.0286
30-Zn- 65	JAN90	244.260d	EC	-0.0075
30-Zn- 69	NOV05	56.4m	β–	0.0000
30-Zn- 69m	NOV05	13.780h	β– (0.00033), IT (0.99967)	-0.0071
31-Ga- 70	NOV07	21.140m	β- (0.9959), EC (0.0041)	-0.0002
31-Ga- 77	JUL99	13.0s	β–	-0.4724
32-Ge- 71	OCT07	11.430d	EC	-0.0402
32-Ge- 71M	JAN08	0.0204s	IT	-0.0361
32-Ge- 73m	JUN06	0.5s	IT	-0.3557
32-Ge- 75	DEC07	1.380h	β-	-0.0284
32-Ge- 75M	DEC07	48.000s	β- (0.00033), IT (0.99967)	-0.033
32-Ge- 80	FEB05	27.0s	β–	-0.0204
33-As- 73	JUN06	80.3d	EC	-0.0344
33-As- 74	OCT90	17.780d	β– (0.34), EC (0.66)	-0.2919
33-As- 76	NOV06	1.092d	β-	0.0406
33-As- 82	JUL99	20.0s	β–	-0.0231
33-As- 82m	JUL99	13.6s	β–	-0.7379
33-As- 85	SEP97	2.040s	β– (0.78), β–n (0.22)	0.0988
34-Se- 75	JAN90	119.640d	EC	-0.1033
34-Se- 77m	JUL06	17.550s	IT	-0.1025
34-Se- 79	OCT07	3.770E+05y	β-	0.0000
34-Se- 79m	JUN01	3.9m	IT (0.99944), β– (0.00056)	-0.0743
34-Se- 81	AUG03	18.390m	β–	0.0027
34-Se- 81m	AUG03	57.280m	β– (0.00068), IT (0.99932)	0.1410
35-Br- 72	AUG03	1.310m	EC	-0.2821
35-Br- 72m	AUG03	10.6s	IT	0.2164
35-Br- 79m	FEB90	4.880s	IT	-0.0283
35-Br- 80	SEP90	17.6m	β– (0.917), EC (0.083)	-0.0134
35-Br- 80m	SEP90	4.410h	IT	-0.1960
35-Br- 82	DEC89	1.472d	β–	0.0729
35-Br- 82m	DEC89	6.090m	β– (0.024), IT (0.976)	0.5001
35-Br- 87	NOV98	55.7s	β– (0.9749), β–n (0.0251)	-0.1976
35-Br- 88	OCT97	16.5s	β– (0.933), β–n (0.067)	0.2554
35-Br- 89	OCT97	4.370s	β– (0.859), β–n (0.141)	0.0534
35-Br- 90	MAR97	1.9s	β– (0.754), β–n (0.246)	0.1331
35-Br- 91	SEP97	0.538s	β– (0.80), β–n (0.20)	0.0274
36-Kr- 79	JAN90	1.460d	EC	-0.0466
36-Kr- 79m	JAN90	50.0s	IT	-0.0728
36-Kr- 81	MAY94	2.10005E+05y	EC	-0.0300
36-Kr- 81m	MAY94	13.2s	EC (2.5000E-05), IT (0.9999750)	0.0187
36-Kr- 83m	OCT93	1.830h	IT	-0.5163
36-Kr- 85	APR94	10.730y	β–	-0.0001
36-Kr- 85m	APR94	4.480h	β– (0.789), IT (0.211)	0.0483

Nuclide	Evaluation Date	$T_{1/2}$	Decay Modes	Q % Deviation
37-Rb– 83	OCT93	86.2d	EC(gd) (0.25), EC(m) (0.75)	-0.0760
37-Rb– 84	FEB94	33.5d	β– (0.032), EC (0.968)	0.0319
37-Rb– 84m	AUG93	20.4m	IT	0.1151
37-Rb– 86	APR94	18.630d	β– (0.9999480), EC (5.2000E-05)	0.0049
37-Rb– 86m	APR94	1.017m	IT	0.0034
37-Rb– 89	AUG01	15.4m	β–	-0.0750
37-Rb– 93	FEB03	5.8s	β– (0.986), β–n (0.014)	-0.0182
37-Rb– 94	JUN98	2.702s	β– (0.899), β–n (0.101)	-0.0527
37-Rb– 95	FEB98	0.381s	β– (0.914), β–n (0.086)	-0.2394
38-Sr- 83	OCT93	1.350d	EC	0.3553
38-Sr- 83m	OCT93	4.950s	IT	-0.0428
38-Sr- 85	FEB92	64.849d	EC	-0.0051
38-Sr- 85m	FEB92	1.127h	EC (0.134), IT (0.866)	0.0031
38-Sr- 87m	OCT06	2.816h	EC (0.003), IT (0.997)	-0.0120
38-Sr- 89	JAN91	50.520d	β–(gd) (0.9999040), β–(m) (9.6400E-05)	0.0000
38-Sr- 90	MAY94	28.869y	β–	0.0000
38-Sr- 92	JUN01	2.710h	β–	-0.0061
38-Sr- 94	SEP03	1.255m	β–	0.0259
39-Y - 87	JUL06	3.325d	EC	0.0077
39-Y – 87m	JUL06	13.370h	EC (0.0157), IT (0.9843)	-0.0408
39-Y - 88	MAR90	106.630d	EC	0.0531
39-Y - 89m	JAN91	16.050s	IT	0.0024
39-Y - 90	NOV07	2.667d	β-	0.0089
39-Y – 90m	NOV07	3.190h	β- (2.1000E-05), IT (0.999979)	-0.002
39-Y - 91	APR94	58.7d	β–	0.0000
39-Y - 91m	APR94	49.720m	IT	-0.0041
39-Y - 96	FEB96	5.370s	β–	-0.0151
39-Y - 96m	FEB96	9.620s	β–	0.0079
39-Y - 97	FEB05	3.750s	β– (0.99945), β–n (0.00055)	0.0105
39-Y - 97m	FEB05	1.170s	β– (0.9925), IT (0.007), β–n (0.0005)	-0.0227
39-Y - 97n	FEB05	0.142s	β– (0.016), IT (0.984)	-0.0264
39-Y - 98	FEB97	0.590s	β– (0.9973), β–n (0.0027)	-0.0432
39-Y - 98m	FEB97	2.0s	β– (0.9656), β–n (0.0344)	-0.2944
39-Y - 99	NOV97	1.477s	β– (0.983), β–n (0.017)	-0.0741
39-Y -104	MAR98	0.130s	β– (0.912230), β–n (0.087769)	#
39-Y -105	MAR98	0.150s	β– (0.80247), β–n (0.19753)	#
40-Zr- 88	MAY94	83.4d	EC	0.0149
40-Zr- 89	JAN91	3.267d	EC(gd) (0.0013), EC(m) (0.9987)	0.0513
40-Zr- 89m	JAN91	4.180m	EC (0.0666), IT (0.9334)	-0.0317
40-Zr- 90m	NOV07	0.808s	IT	-0.0421
40-Zr- 93	JUL96	1.53003E+06y	β–(gd) (0.025), β–(m) (0.975)	1.2384
40-Zr- 95	NOV90	64.030d	β–(gd) (0.989), β–(m) (0.011)	-0.0121
40-Zr- 99	AUG03	2.2s	β–(gd) (0.632), β–(m) (0.368)	-0.0510
40-Zr-105	JAN98	0.6s	β– (0.986), β–n (0.014)	#
40-Zr-106	MAR98	0.9s	β– (0.984760), β–n (0.015242)	#
40-Zr-107	MAR98	0.240s	β– (0.962870), β–n (0.037127)	#
41-Nb- 90	NOV07	14.590h	EC (0.981), EC (0.019)	-0.0108
41-Nb- 90m	NOV07	18.810s	IT	0.0185
41-Nb- 90n	NOV07	6.22000E-03s	IT	0.0158
41-Nb– 91	APR94	680.016y	EC	-0.0021

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41-Nb– 91m	APR94	60.9d	IT (0.976), EC (0.024)	-0.1628
41-Nb– 92	SEP93	3.50009E+07y	EC	0.0187
41-Nb– 92m	SEP93	10.150d	EC	-0.0254
41-Nb– 93m	JUL96	16.126y	IT	-0.3678
41-Nb– 94	JAN90	1.99867E+04y	β–	-0.0014
41-Nb– 94m	JAN90	6.260m	β– (0.005), IT (0.995)	-0.0290
41-Nb– 95	NOV90	34.975d	β–	0.0025
41-Nb– 95m	NOV90	3.608d	β– (0.034), IT (0.966)	-0.0661
41-Nb– 96	OCT05	23.350h	β–	0.0239
41-Nb–100	DEC96	1.4s	β–	0.0733
41-Nb–100m	DEC96	2.9s	β–	-0.0167
41-Nb–109	MAR98	0.190s	β– (0.87347), β–n (0.12653)	#
42-Mo- 93	MAR90	3.01170E+03y	EC(gd) (0.15), EC(m) (0.85)	-0.0074
42-Mo- 93m	MAR90	6.850h	EC (0.0012), IT (0.9988)	0.0162
42-Mo- 99	OCT90	2.748d	β–(gd) (0.119), β–(m) (0.881)	-0.0098
42-Mo-103	AUG01	1.132m	β–	-0.0096
42-Mo-109	MAR98	0.5s	β– (0.9947), β–n (0.0053)	#
42-Mo-111	MAR98	0.5s	β– (0.9897), β–n (0.0103030)	#
42-Mo-112	MAR98	1.0s	β– (0.97921), β–n (0.0207880)	#
43-Tc- 97	FEB96	2.60006E+06y	EC	-0.0047
43-Tc- 97m	FEB96	90.2d	IT	0.0621
43-Tc- 99m	JUL90	6.010h	β– (3.7000E-05), IT (0.9999630)	0.0470
43-Tc-113	MAR98	0.130s	β– (0.928140), β–n (0.071864)	#
43-Tc-114	MAR98	0.2s	β– (0.934640), β–n (0.065358)	#
43-Tc-115	MAR98	0.270s	β– (0.85663), β–n (0.14337)	#
43-Tc-116	MAR98	0.120s	β– (0.87777), β–n (0.12223)	#
43-Tc-99	JUL90	2.11305E+05y	β–	0.0000
44-Ru-103	MAY90	39.260d	β–(gd) (0.0115), β–(m) (0.9885)	-0.0914
44-Ru-115	MAR98	0.7s	β– (0.997720), β–n (0.002276)	#
44-Ru-116	MAR98	1.7s	β– (0.989190), β–n (0.010811)	#
44-Ru-117	MAR98	0.340s	β– (0.979490), β–n (0.020509)	#
44-Ru-118	MAR98	0.7s	β– (0.958910), β–n (0.041092)	#
44-Ru-119	JAN02	0.190s	β– (0.95642), β–n (0.04358)	#
45-Rh-101	OCT06	3.2y	EC	-0.0854
45-Rh-101m	OCT06	4.340d	EC (0.9256), IT (0.0744)	-0.0180
45-Rh-102	DEC90	2.902y	EC	-0.4531
45-Rh-102m	DEC90	208.0d	β– (0.20), EC (0.75), IT (0.05)	0.0748
45-Rh-103m	MAY94	56.115m	IT	-0.3866
45-Rh-104	JUN90	42.3s	β– (0.9955), EC (0.0045)	0.0233
45-Rh-104m	JUN90	4.340m	β– (0.0013), IT (0.9987)	-0.1843
45-Rh-105	JAN94	1.474d	β–	-0.0546
45-Rh-105m	JAN94	40.0s	IT	-0.0461
45-Rh-106	AUG96	30.1s	β–	-0.0243
45-Rh-106m	AUG96	2.2h	β–	-0.0487
45-Rh-110	SEP03	28.5s	β–	0.0172
45-Rh-110m	SEP03	3.2s	β–	0.1721
45-Rh-111	SEP04	12.0s	β–	0.0125
45-Rh-118	MAR98	0.320s	β– (0.970830), β–n (0.029167)	#
45-Rh-120	MAR98	0.170s	β– (0.940720), β–n (0.059282)	#
45-Rh-121	MAR98	0.250s	β– (0.86432), β–n (0.13568)	#
46-Pd-103	MAY94	16.980d	EC(gd) (0.00026), EC(m) (0.99974)	-0.0398

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46-Pd-107	NOV93	6.50013E+06y	β–	0.0000
46-Pd-107m	NOV93	21.3s	IT	0.0330
46-Pd-109	MAR98	13.460h	β–(gd) (0.00046), β–(m) (0.99954)	0.0090
46-Pd-109m	FEB98	4.710m	IT	0.0367
46-Pd-112	JAN97	20.3h	β–	-0.0306
46-Pd-113	OCT04	1.517m	β–(gd) (0.050), β–(m) (0.950)	-0.1194
46-Pd-113m	OCT04	0.3s	IT	0.3404
46-Pd-121	MAR98	0.6s	β– (0.99728), β–n (0.0027220)	#
47-Ag-105	JAN94	41.3d	EC	-0.0536
47-Ag-105m	JAN94	7.230m	EC (0.0034), IT (0.9966)	-0.6547
47-Ag-106	JAN94	24.0m	β– (0.005), EC (0.995)	-0.0051
47-Ag-106m	JAN94	8.460d	EC	0.9682
47-Ag-107m	JAN97	44.1s	IT	-0.0525
47-Ag-108	OCT90	2.4m	β– (0.971), EC (0.029)	0.0204
47-Ag-108m	JAN92	418.010y	EC (0.913), IT (0.087)	-0.0190
47-Ag-109m	JUL06	39.7s	IT	-0.0051
47-Ag-110	NOV91	24.7s	β– (0.997), EC (0.003)	-0.0009
47-Ag-110m	NOV91	249.791d	β– (0.9873), IT (0.0127)	-0.3356
47-Ag-111	JUL94	7.450d	β–	0.0002
47-Ag-111m	JUL94	1.080m	β– (0.005), IT (0.995)	-0.1750
47-Ag-114	OCT98	4.7s	β–	-0.1883
47-Ag-114m	OCT98	1.50000E-03s	IT	0.0039
47-Ag-115	MAY98	20.5m	β–(gd) (0.88), β–(m) (0.12)	0.0434
47-Ag-115m	FEB03	18.6s	β–(gd) (0.767), β–(m) (0.023), IT (0.21)	0.1918
48-Cd-107	FEB03	6.520h	EC(gd) (0.00064), EC(m) (0.99936)	-0.0289
48-Cd-109	MAR90	1.267y	EC	0.0330
48-Cd-111m	JAN91	48.540m	IT	-0.0834
48-Cd-113	DEC07	7.80000E+15y	β-	0.0000
48-Cd-113m	DEC07	14.600y	β- (0.9988), IT (0.0012)	0.0000
48-Cd-115	MAY94	2.225d	β–(gd) (7.0000E-07), β–(m) (0.9999990)	-0.0224
48-Cd-115m	MAY94	44.6d	β–(gd) (0.99993), β–(m) (7.0000E-05)	-0.0050
49-In-111	JAN91	2.805d	EC(gd) (0.9999140), EC(m) (8.6000E-05)	0.0372
49-In-111m	JAN91	7.9m	IT	-0.0507
49-In-112	JAN97	14.7m	β– (0.44), EC (0.56)	0.1052
49-In-112m	JAN97	20.7m	IT	-0.1202
49-In-113m	FEB91	1.658h	IT	0.0014
49-In-114	FEB92	1.198m	β– (0.995), EC (0.005)	-0.0031
49-In-114m	FEB92	50.0d	EC (0.035), IT (0.965)	-0.1894
49-In-114n	FEB92	0.043s	IT	-0.0062
49-In-115	MAR90	4.41009E+14y	β–	0.0000
49-In-115m	MAY94	4.486h	β– (0.0505), IT (0.9495)	0.0066
49-In-116	JAN92	14.2s	β–	0.6261
49-In-116m	JAN92	54.6m	β–	0.1921
49-In-116n	JAN92	2.170s	IT	0.0632
50-Sn-110	DEC00	4.1h	EC	0.0064
50-Sn-113	FEB91	115.090d	EC(gd) (1.0000E-04), EC(m) (0.9999)	0.0204
50-Sn-113m	FEB91	20.9m	EC (0.089), IT (0.911)	-0.2109

Nuclide	Evaluation Date	$T_{1/2}$	Decay Modes	Q % Deviation
50-Sn-117m	JAN90	13.6d	IT	-0.0006
50-Sn-119m	JAN92	293.0d	IT	-0.1028
50-Sn-121	NOV07	1.125d	β-	0.0000
50-Sn-121m	NOV07	43.900y	β- (0.224), IT (0.776)	-0.0914
50-Sn-123	APR91	129.2d	β–	-0.0042
50-Sn-123m	APR91	40.1m	β–	-0.0694
50-Sn-125	OCT91	9.640d	β–	-0.0725
50-Sn-125m	OCT91	9.520m	β–	0.1417
50-Sn-126	JUL01	2.42005E+05y	β–(m) (0.332), β–(n) (0.668)	0.0675
50-Sn-129	SEP04	2.230m	β–	-0.0200
50-Sn-129m	SEP04	7.2m	β–(gd) (0.69), β–(m) (0.31)	-0.0531
50-Sn-130	JAN05	3.730m	β–	-0.0085
50-Sn-130m	JAN05	1.7m	β–(gd) (0.84), β–(m) (0.16)	0.0458
51-Sb–119	NOV93	1.596d	EC	0.0186
51-Sb–120	NOV93	15.9m	EC	-0.1123
51-Sb–120m	NOV93	5.760d	EC	-0.0684
51-Sb–122	JUL91	2.696d	β– (0.9763), EC (0.0237)	0.0041
51-Sb–122m	JUL91	4.190m	IT	-0.0135
51-Sb–124	DEC90	60.240d	β–	-0.0495
51-Sb–124m	DEC90	1.550m	β– (0.25), IT (0.75)	-0.3407
51-Sb–124n	DEC90	20.2m	IT	-0.4979
51-Sb–125	JAN92	2.759y	β–(gd) (0.764), β–(m) (0.236)	0.0434
51-Sb–126	JUL01	12.410d	β–	-0.0635
51-Sb–126m	JUL01	19.1m	IT (0.14), β– (0.86)	-0.1708
51-Sb–126n	JUL01	11.0s	IT	-0.5031
51-Sb–127	OCT96	3.840d	β–(gd) (0.832), β–(m) (0.168)	-0.0431
51-Sb–129	MAR92	4.360h	β–(gd) (0.834), β–(m) (0.166)	-0.6673
51-Sb–129m	MAR92	17.7m	β–(gd) (0.02), β–(m) (0.83), IT (0.15)	Incomplete
51-Sb–135	JUL98	1.740s	β– (0.843), β–n (0.157)	-0.0198
51-Sb–141	MAR98	0.3s	β– (0.869), β–n (0.131)	#
52-Te-121	JUL01	19.160d	EC	0.0226
52-Te-121m	JUL01	154.0d	EC (0.113), IT (0.887)	-0.1799
52-Te-125m	JUL91	58.0d	IT	-0.0051
52-Te-127	OCT96	9.350h	β–	-0.0037
52-Te-127m	OCT96	109.0d	IT (0.976), β– (0.024)	-0.0908
52-Te-129	JUN92	1.160h	β–	-0.0619
52-Te-129m	JUN92	33.8d	β– (0.31), IT (0.69)	-0.2257
52-Te-132	OCT96	3.230d	β–	0.1077
53-I -125	JAN92	59.430d	EC	0.0709
53-I -126	OCT90	12.980d	β– (0.437), EC (0.563)	0.0678
53-I -132	DEC96	2.283h	β–	-0.0832
53-I -132m	NOV96	1.383h	IT (0.86), β– (0.14)	-0.3723
53-I -137	DEC97	24.510s	β– (0.935), β–n (0.065)	0.1276
53-I -138	FEB03	6.460s	β– (0.947), β–n (0.053)	-0.1955
53-I -139	NOV97	2.3s	β– (0.902), β–n (0.098)	-0.0552
54-Xe-125	OCT91	16.9h	EC	-0.0292
54-Xe-125m	OCT91	56.0s	IT	0.0606
54-Xe-127	MAR91	36.440d	EC	-0.1451
54-Xe-127m	MAR91	1.160m	IT	-0.0383
54-Xe-129m	SEP94	8.870d	IT	0.1143

Nuclide	Evaluation Date	$T_{1/2}$	Decay Modes	Q % Deviation
54-Xe-131m	SEP94	11.870d	IT	0.0676
54-Xe-133	SEP93	5.243d	β–	0.0299
54-Xe-133m	SEP93	2.190d	IT	0.0213
55-Cs-123	MAR05	5.910m	EC	-0.0424
55-Cs-123m	MAR05	1.7s	IT	-0.0020
55-Cs-129	SEP94	1.342d	EC	0.0670
55-Cs-131	SEP94	9.690d	EC	0.0477
55-Cs-132	AUG94	6.530d	β– (0.018), EC (0.982)	0.0165
55-Cs-134	MAR92	2.065y	β– (0.9999970), EC (3.0000E-06)	0.0823
55-Cs-134m	MAR92	2.908h	IT	-0.0812
55-Cs-135	JUL91	2.40005E+06y	β–	0.0000
55-Cs-135m	JUL91	53.0m	IT	-0.0280
55-Cs-136	OCT91	13.030d	β–	-0.2422
55-Cs-136m	OCT91	19.0s	β– (0.50), IT (0.50)	Incomplete
55-Cs-137	NOV90	30.172y	β–(gd) (0.054), β–(m) (0.946)	0.0000
56-Ba-126	JAN01	1.667h	EC	-0.1958
56-Ba-129	FEB96	2.380h	EC	-0.0730
56-Ba-129m	FEB96	2.140h	EC	0.0550
56-Ba-131	NOV94	11.550d	EC	-0.0195
56-Ba-131m	NOV94	14.6m	IT	0.1392
56-Ba-133	JAN92	10.574y	EC	0.0810
56-Ba-133m	MAR92	1.592d	EC (0.0001010), IT (0.9998990)	-0.0816
56-Ba-137m	NOV90	2.553m	IT	0.0176
57-La-137	JUN01	6.00014E+04y	EC	0.0353
57-La-140	OCT96	1.679d	β–	-0.0108
57-La-152	MAR98	0.280s	β– (0.93961), β–n (0.0603930)	#
58-Ce-139	MAY92	137.650d	EC	0.1622
58-Ce-139m	MAY92	56.1s	IT	0.0029
58-Ce-145	JUL01	2.950m	β–	0.1188
58-Ce-147	NOV96	57.0s	β–	0.0269
58-Ce-149	OCT04	5.3s	β–	0.0777
58-Ce-153	MAR98	1.5s	β– (0.99378), β–n (0.0062190)	#
58-Ce-154	MAR98	2.0s	β– (0.99363), β–n (0.0063730)	#
58-Ce-158	MAR98	1.0s	β– (0.9945), β–n (0.0055)	#
59-Pr-143	SEP96	13.560d	β–	0.0000
59-Pr-144	SEP96	17.280m	β–	0.0382
59-Pr-144m	SEP96	6.9m	IT (0.9993), β– (0.0007)	-0.0860
59-Pr-150	DEC96	6.1s	β–	-0.6261
59-Pr-156	MAR98	0.5s	β– (0.97283), β–n (0.02717)	#
59-Pr-157	MAR98	0.3s	β– (0.936130), β–n (0.063874)	#
60-Nd-140	NOV93	3.370d	EC	0.1286
60-Nd-147	JUN94	11.020d	β–	0.0450
60-Nd-157	MAR98	2.5s	β–	#
60-Nd-158	MAR98	0.7s	β– (0.99995), β–n (5.3000E-05)	#
60-Nd-159	MAR98	0.5s	β– (0.99764), β–n (0.0023610)	#
60-Nd-160	MAR98	0.3s	β– (0.99053), β–n (0.0094690)	#
61-Pm-143	NOV93	266.0d	EC	0.0493
61-Pm-144	AUG93	363.0d	EC	0.0484
61-Pm-145	JUL91	17.7y	EC (1.00), α (2.8000E-09)	0.1990
61-Pm-146	JUL94	5.531y	β– (0.34), EC (0.66)	-0.3961
61-Pm-147	JUN94	2.622y	β–	0.0000
61-Pm-148	OCT93	5.368d	β–	0.0064

Nuclide	Evaluation Date	$T_{1/2}$	Decay Modes	Q % Deviation
61-Pm-148m	OCT93	41.050d	β– (0.95), IT (0.05)	-0.0147
61-Pm-149	FEB94	2.212d	β–	0.2080
61-Pm-151	AUG94	1.171d	β–	0.4059
61-Pm-152	JAN97	4.120m	β–	-0.3799
61-Pm-152m	JAN97	7.5m	β–	-0.7796
61-Pm-152n	JAN97	14.4m	β–	-0.0401
61-Pm-155	MAR05	41.5s	β–	Incomplete
61-Pm-159	MAR98	3.0s	β– (0.999820), β–n (0.000185)	#
61-Pm-160	MAR98	2.0s	β– (0.997320), β–n (0.002676)	#
62-Sm-145	JUL91	340.0d	EC	0.0659
62-Sm-146	JUL90	1.00002E+08y	α	-0.0199
62-Sm-147	SEP96	1.06002E+11y	α	-0.0023
62-Sm-151	FEB94	90.002y	β–	-0.0009
62-Sm-153	AUG94	1.929d	β–	0.1640
63-Eu-149	FEB94	93.1d	EC	0.1254
63-Eu-150	NOV94	36.359y	EC	0.0823
63-Eu-150m	NOV94	12.8h	β– (0.88), EC (0.12)	0.5503
63-Eu-152	JUL92	13.523y	β– (0.28), EC (0.72)	-0.1502
63-Eu-152m	JUL92	9.275h	β– (0.72), EC (0.28)	-0.6753
63-Eu-152n	JUL92	1.6h	IT	0.0207
63-Eu-154	MAY92	8.593y	β– (0.9998), EC (0.0002)	0.0416
63-Eu-154m	MAY92	46.4m	IT	0.0927
63-Eu-155	DEC91	4.846y	β–	0.1705
63-Eu-156	OCT94	15.2d	β–	-0.2787
64-Gd-150	DEC94	1.82004E+06y	α	0.0119
64-Gd-151	FEB94	124.0d	EC (1.00), α (1.0000E-08)	-0.1917
64-Gd-153	AUG94	240.5d	EC	-0.0495
64-Gd-163	SEP04	1.133m	β–	0.0550
65-Tb–146	JAN05	8.0s	EC	-0.0027
65-Tb–146m	JAN05	24.0s	EC	-0.1118
65-Tb–156	FEB96	5.170d	EC	-0.3867
65-Tb–156m	FEB96	1.017d	IT	0.5785
65-Tb–156n	FEB96	5.1h	EC (0.0019), IT (0.9981)	-0.0964
65-Tb–157	MAR91	99.002y	EC	1.2277
65-Tb–158	DEC05	180.0y	β– (0.168), EC (0.832)	-0.0411
65-Tb–158m	DEC05	10.8s	IT	0.1545
65-Tb–160	NOV05	72.3d	β–	0.0185
65-Tb–161	OCT96	6.890d	β–	-0.0324
66-Dy-157	OCT91	8.140h	EC	-0.0226
66-Dy-159	APR91	144.4d	EC	0.0906
66-Dy-166	NOV07	3.400d	β-	0.0542
67-Ho-160	FEB03	25.3m	EC	-0.2337
67-Ho-160m	MAR96	5.0h	IT (0.65), EC (0.35)	-0.502
67-Ho-160n	MAR96	2.9s	IT	0.2220
67-Ho-161	OCT96	2.480h	EC	0.0565
67-Ho-161m	OCT96	6.770s	IT	0.1297
67-Ho-163	JUN01	4.57009E+03y	EC	Incomplete
67-Ho-163m	JUN01	1.1s	IT	0.0373
67-Ho-164	DEC00	28.6m	β– (0.517), EC (0.483)	0.0101
67-Ho-164m	DEC00	37.6m	IT	0.0498
67-Ho-170	AUG99	2.780m	β–	-0.4097

Nuclide	Evaluation Date	$T_{1/2}$	Decay Modes	Q % Deviation
67-Ho-170m	AUG99	43.0s	β−	-0.3870
68-Er-167m	JUL06	2.270s	IT	0.0743
68-Er-172	JAN01	2.054d	β−	0.2611
69-Tm-167	JUL06	9.246d	EC(gd) (0.0171), EC(m) (0.9829)	0.1193
69-Tm-168	DEC06	90.0d	β− (0.0001), EC (0.9999)	0.0759
69-Tm-170	NOV07	128.600d	β- (0.99862),EC (0.00138)	0.0041
69-Tm-171	JAN06	1.917y	β−	0.0017
69-Tm-172	NOV05	2.650d	β−	0.1605
70-Yb−175	NOV94	4.185d	β−	-0.0012
70-Yb-176m	NOV07	11.400s	IT	-0.0071
71-Lu-171	MAR94	8.250d	EC	0.4900
71-Lu-171m	NOV93	1.3m	IT	-0.0305
71-Lu-172	DEC93	6.7d	EC	-0.4760
71-Lu-172m	NOV93	3.7m	IT	-0.0295
71-Lu-173	JUL94	1.336y	EC	-0.2844
71-Lu-174	NOV93	3.559y	EC	-0.1885
71-Lu-174m	NOV93	142.0d	EC (0.0058), IT (0.9942)	0.2587
71-Lu-177	FEB94	6.7d	β−	0.0612
71-Lu-177m	MAY94	160.3d	β− (0.774), IT (0.226)	0.2669
72-Hf-173	JUL94	23.9h	EC	0.0977
72-Hf-174	JUL91	2.00004E+15y	α	0.0155
72-Hf-175	FEB92	70.0d	EC	0.0337
72-Hf-177m	FEB94	1.080s	IT	0.5106
72-Hf-177n	FEB94	51.4m	IT	-0.2990
72-Hf-178m	AUG98	4.0s	IT	0.0013
72-Hf-178n	AUG98	31.001y	IT	0.1450
72-Hf-179m	OCT05	18.670s	IT	0.0568
72-Hf-179n	OCT05	25.1d	IT	0.0382
72-Hf-180m	AUG98	5.5h	β− (0.0031), IT (0.9969)	-0.2523
72-Hf-181	JAN92	42.380d	β−	0.0975
73-Ta-177	SEP94	2.350d	EC	-0.0203
73-Ta-179	MAR91	1.610y	EC	0.8418
73-Ta-180	MAR91	8.080h	β− (0.181), EC (0.819)	0.0321
73-Ta-180m	MAR91	1.80004E+15y	β− (0.20), EC (0.80)	0.1639
73-Ta-182	DEC91	114.7d	β−	-0.0057
73-Ta-182m	DEC91	0.283s	IT	0.1654
73-Ta-182n	DEC91	15.840m	IT	0.8531
73-Ta-183	JUN94	5.090d	β−(gd) (0.966), β−(m) (0.034)	0.0328
74-W -176	SEP03	2.5h	EC	0.1347
74-W -178	SEP94	21.6d	EC	1.2871
74-W -181	AUG91	120.980d	EC	0.0684
74-W -183m	JUN94	5.250s	IT	0.0409
74-W -185	JAN91	75.1d	β−	0.0001
74-W -185m	JAN91	1.667m	IT	-0.1514
74-W -187	OCT91	23.850h	β−	0.0631
74-W -188	OCT05	69.780d	β−	0.0013
75-Re-183	NOV06	70.0d	EC	0.2007
75-Re-183m	NOV06	1.03000E-03s	IT	0.1037
75-Re-184	NOV07	35.400d	EC	0.0468
75-Re-184m	NOV05	168.0d	EC (0.252), IT (0.748)	0.1530
75-Re-186	JUN06	3.750d	β− (0.9313), EC (0.0687)	0.0046
75-Re-186m	JUN06	1.90000E+05y	IT	-0.4061

Nuclide	Evaluation Date	$T_{1/2}$	Decay Modes	Q % Deviation
75-Re-191	MAR96	9.7m	β–	0.0000
75-Re-192	MAR96	6.2s	β–	0.0566
76-Os-180	OCT03	21.5m	EC	0.0346
76-Os-185	SEP98	93.8d	EC	0.0570
76-Os-189m	NOV07	5.810h	IT	-0.2464
76-Os-190m	SEP98	9.9m	IT	0.0011
76-Os-191	NOV05	15.3d	β–	0.0000
76-Os-191m	NOV05	13.1h	IT	-0.0030
76-Os-194	JUL06	6.0y	β–	-0.1669
76-Os-195	APR96	6.5m	β–	-0.0396
76-Os-196	AUG03	34.9m	β–	-0.0177
77-Ir-187	OCT00	10.5h	EC	-0.0621
77-Ir-190	FEB03	12.0d	EC	-0.1063
77-Ir-190m	SEP98	1.120h	IT	-0.0849
77-Ir-190n	SEP98	3.087h	IT (0.086), EC (0.914)	0.0893
77-Ir-191m	NOV05	4.9s	IT	0.0772
77-Ir-191n	OCT00	5.5s	IT	0.0097
77-Ir-192	SEP03	73.822d	β– (0.952), EC (0.048)	0.1323
77-Ir-192m	SEP03	1.440m	β– (0.0001750), IT (0.9998250)	-0.0780
77-Ir-192n	SEP03	241.0y	IT	0.0069
77-Ir-193m	OCT06	10.540d	IT	-0.0699
77-Ir-197	OCT00	5.8m	β–	-0.2184
77-Ir-197m	OCT00	8.9m	β– (0.9975), IT (0.0025)	0.0004
78-Pt-190	JAN08	6.50E+11y	α	-0.0157
78-Pt-193	FEB96	50.001y	EC	2.0682
78-Pt-193m	FEB96	4.340d	IT	-0.3390
78-Pt-195m	OCT06	4.1d	IT	0.2207
78-Pt-197	NOV00	19.892h	β–	0.1082
78-Pt-197m	NOV00	1.588h	β– (0.033), IT (0.967)	0.1698
78-Pt-202	AUG03	1.833d	β–	0.0000
79-Au-192m	SEP03	0.029s	IT	0.3330
79-Au-192n	SEP03	0.160s	IT	0.0100
79-Au-195	OCT06	186.094d	EC	0.8595
79-Au-195m	OCT06	30.5s	IT	0.0121
79-Au-197m	NOV00	7.740s	IT	-0.0267
79-Au-198	DEC87	2.694d	β–	0.0018
79-Au-198m	APR92	2.3d	IT	Incomplete
79-Au-199	JUN01	3.139d	β–	-0.0640
80-Hg-190	FEB03	20.0m	EC	0.5330
80-Hg-194	JUL06	444.001y	EC	2.4780
80-Hg-197	NOV00	2.692d	EC	0.1223
80-Hg-197m	NOV00	23.9h	EC (0.086), IT (0.914)	0.0878
80-Hg-199m	AUG98	42.1m	IT	0.0441
80-Hg-203	MAR91	46.595d	β–	0.0271
80-Hg-205	JUL01	5.2m	β–	-0.0431
81-Tl-193	JAN01	21.8m	EC	-0.0502
81-Tl-193m	JAN01	2.110m	EC (0.25), IT (0.75)	-0.0042
81-Tl-201	SEP93	3.041d	EC	Incomplete
81-Tl-202	APR94	12.240d	EC	0.0885
81-Tl-204	NOV91	3.790y	β– (0.978), EC (0.022)	0.0033
82-Pb–201	FEB03	9.4h	EC	0.3405
82-Pb–201m	OCT98	1.017m	IT	0.1220

Nuclide	Evaluation Date	$T_{1/2}$	Decay Modes	Q % Deviation
82-Pb–202	DEC93	5.30010E+04y	EC	1.6745
82-Pb–202m	DEC93	3.570h	EC (0.091), IT (0.909)	-0.3569
82-Pb–203	MAR94	2.162d	EC	0.0605
82-Pb–203m	MAR94	6.290s	IT	-0.0116
82-Pb–203n	MAR94	0.480s	IT	0.0625
82-Pb–204	NOV91	1.40003E+17y	α	-0.0097
82-Pb–204m	NOV91	1.125h	IT	0.0780
82-Pb–205	DEC93	1.53003E+07y	EC	1.9227
83-Bi-207	AUG91	31.760y	EC	0.1833
83-Bi-208	FEB96	3.68008E+05y	EC	0.0635
84-Po-208	FEB96	2.930y	EC (1.8100E-05), α (0.9999820)	-0.0380
86-Rn-223	DEC92	24.2m	$\beta-$	-0.3329
90-Th-228	SEP02	1.913y	α	-0.0175
90-Th-231	MAR95	1.063d	$\beta-$	-0.7156
93-Np-239	MAY91	2.355d	$\beta-$	-0.1364
95-Am-241	FEB01	432.808y	α (1.00), SF (3.7700E-12)	0.2443
95-Am-243	FEB03	7.36498E+03y	α (1.00), SF (3.7000E-11)	-0.0218

\# Decay data measurements were unavailable, and therefore theoretical data were adopted from a combination of US ENDF/B-VI (21), Takahashi *et al.* (22) and Audi *et al.* (23).

Incomplete files are described in Section 4.2 of the main text.

Table 2. Summary of Spectral Data

Continuum spectra are indicated by the letter 'c' following the number of discrete spectral lines. Thus, '15c' indicates that there are 15 discrete lines followed by a continuum spectrum, and '0c' indicates that only a continuum spectrum is present.

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
1-H - 3	3.89105E+08	5.71	0.00	0.00	-	1	-	-	-	-	-	-	-
2-He- 6	8.08100E-01	1561.31	5.64	0.00	-	1	-	-	-	-	-	-	-
2-He- 8	1.22000E-01	4448.62	884.97	141.37	1	2	-	-	1	-	-	-	-
3-Li- 8	8.38000E-01	6204.62	32.98	3125.25	-	1	-	1	-	-	-	-	-
3-Li- 9	1.78300E-01	5696.25	29.90	0.00	-	5	-	-	-	-	-	-	-
4-Be- 7	4.59994E+06	0.00	49.30	0.00	1	-	2	-	-	-	-	-	-
4-Be- 8	7.00000E-17	0.00	0.00	91.90	-	-	-	1	-	-	-	-	-
4-Be- 10	5.04922E+13	252.21	0.00	0.00	-	1	-	-	-	-	-	-	-
4-Be- 11	1.38100E+01	4647.31	1418.78	36.27	8	6	-	1	-	-	-	-	-
5-B - 12	2.02000E-02	6308.41	90.56	6.64	1	4	-	2	-	-	-	-	-
5-B - 13	1.73300E-02	6278.30	313.53	9.76	1	5	-	-	4	-	-	-	-
6-C - 14	1.80825E+11	49.48	0.00	0.00	-	1	-	-	-	-	-	-	-
6-C - 15	2.44900E+00	2856.16	3621.81	0.00	5	6	-	-	-	-	-	-	-
7-N - 13	5.97900E+02	490.11	1020.70	0.00	-	-	1	-	-	-	-	1	2
7-N - 16	7.13000E+00	2679.45	4621.50	0.03	10	7	-	3	-	-	-	-	-
7-N - 17	4.17000E+00	1697.81	44.51	901.13	2	9	-	2	6	-	-	-	-
8-O - 19	2.69100E+01	1709.60	1004.57	0.00	8	3	-	-	-	-	-	-	-
9-F - 18	6.58200E+03	241.49	987.27	0.00	-	-	1	-	-	-	-	1	2
9-F - 20	1.10300E+01	2467.27	1644.68	0.00	2	2	-	-	-	-	-	-	-
9-F - 21	4.15800E+00	2341.83	556.87	0.00	15	7	-	-	-	-	-	4	1
10-Ne- 23	3.72000E+01	1890.05	172.79	0.00	5	4	-	-	-	-	-	-	-

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
11-Na- 22	8.21444E+07	195.76	2198.92	0.00	1	-	2	-	-	-	-	4	2
11-Na- 24	5.38756E+04	553.60	4122.24	0.00	6	3	-	-	-	-	-	5	2
11-Na- 24m	2.02000E-02	13.77	470.00	0.00	1	1	-	-	-	-	-	-	-
11-Na- 25	5.96000E+01	1496.49	436.90	0.00	10	5	-	-	-	-	-	-	-
11-Na- 26	1.08000E+00	3329.45	2180.29	0.00	19	9	-	-	-	-	-	-	-
12-Mg- 27	5.67480E+02	699.62	894.99	0.00	3	2	-	-	-	-	-	-	-
12-Mg- 28	7.52400E+04	197.86	1379.96	0.00	8	3	-	-	-	-	-	5	3
13-Al- 26	2.27215E+13	446.15	2678.09	0.00	3	-	2	-	-	-	-	2	3
13-Al- 26m	6.34500E+00	1433.75	1026.13	0.00	-	-	1	-	-	-	-	2	3
13-Al- 28	1.34460E+02	1237.60	1782.85	0.00	1	1	-	-	-	-	-	-	-
13-Al- 29	3.93600E+02	972.76	1380.92	0.00	7	4	-	-	-	-	-	-	-
13-Al- 30	3.65000E+00	2290.18	3512.41	0.00	17	7	-	-	-	-	-	-	-
14-Si- 31	9.43200E+03	593.74	2.17	0.00	1	2	-	-	-	-	-	-	-
14-Si- 32	1.04140E+10	64.68	0.00	0.00	-	1	-	-	-	-	-	-	-
15-P - 32	1.23293E+06	692.92	1.71	0.00	-	1	-	-	-	-	-	-	-
15-P - 33	2.19456E+06	76.57	0.00	0.00	-	1	-	-	-	-	-	-	-
15-P - 34	1.24000E+01	2284.55	347.48	0.00	6	5	-	-	-	-	-	-	-
16-S - 35	7.56000E+06	48.83	0.00	0.00	-	1	-	-	-	-	-	-	-
16-S - 37	2.99400E+02	793.24	2936.91	0.00	4	4	-	-	-	-	-	-	-
17-Cl- 34	1.52600E+00	2043.76	1029.20	0.00	-	-	1	-	-	-	-	2	4
17-Cl- 34m	1.92600E+03	441.40	1979.11	0.00	9	-	5	-	-	-	-	8	7
17-Cl- 36	9.68818E+12	246.09	0.03	0.00	-	1	1	-	-	-	-	2	4
17-Cl- 38	2.23200E+03	1522.99	1493.73	0.00	3	3	-	-	-	-	-	-	-
17-Cl- 38m	7.15000E-01	0.43	671.30	0.00	1	-	-	-	-	-	-	5	3
17-Cl- 39	3.33600E+03	822.65	1454.37	0.00	19	7	-	-	-	-	-	12	3

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
18-Ar- 37	3.02746E+06	2.36	0.32	0.00	-	-	1	-	-	-	-	3	3
18-Ar- 39	8.48899E+09	218.65	0.00	0.00	-	1	-	-	-	-	-	-	-
18-Ar- 41	6.57600E+03	463.60	1284.47	0.00	2	3	-	-	-	-	-	6	3
18-Ar- 42	1.04140E+09	232.82	0.00	0.00	-	1	-	-	-	-	-	-	-
19-K - 38	4.56600E+02	1201.32	3190.50	0.00	3	-	2	-	-	-	-	3	4
19-K - 38m	9.24000E-01	2312.41	1030.62	0.00	-	-	1	-	-	-	-	3	4
19-K - 40	4.03937E+16	521.75	157.20	0.00	1	1	2	-	-	-	-	3	4
19-K - 42	4.45320E+04	1417.12	296.38	0.00	8	5	-	-	-	-	-	-	-
19-K - 43	7.99200E+04	309.56	966.16	0.00	10	5	-	-	-	-	-	12	3
19-K - 44	1.32780E+03	1436.10	2391.27	0.00	122	33	-	-	-	-	-	72	3
20-Ca- 41	3.25043E+12	2.84	0.44	0.00	-	-	1	-	-	-	-	3	3
20-Ca- 45	1.40573E+07	77.22	0.00	0.00	1	2	-	-	-	-	-	6	3
20-Ca- 47	3.92083E+05	344.61	1060.41	0.00	7	4	-	-	-	-	-	6	3
20-Ca- 49	5.23200E+02	869.51	3167.14	0.00	11	6	-	-	-	-	-	-	-
21-Sc- 44	1.41372E+04	595.65	2136.46	0.00	5	-	3	-	-	-	-	6	4
21-Sc- 44m	2.10960E+05	32.82	275.27	0.00	4	-	1	-	-	-	-	12	6
21-Sc- 45m	3.25000E-01	11.71	0.70	0.00	1	-	-	-	-	-	-	6	3
21-Sc- 46	7.23946E+06	112.24	2009.54	0.00	3	2	-	-	-	-	-	9	3
21-Sc- 46m	1.87000E+01	58.90	82.96	0.00	1	-	-	-	-	-	-	6	3
21-Sc- 47	2.89094E+05	162.53	108.53	0.00	1	2	-	-	-	-	-	6	3
21-Sc- 48	1.57212E+05	219.59	3349.60	0.00	5	2	-	-	-	-	-	-	-
21-Sc- 49	3.43200E+03	819.88	3.34	0.00	2	3	-	-	-	-	-	-	-
21-Sc- 50	1.02500E+02	1624.13	3198.10	0.00	10	8	-	-	-	-	-	-	-
21-Sc- 50m	3.50000E-01	40.69	264.40	0.00	2	1	-	-	-	-	-	6	3
22-Ti- 45	1.10880E+04	373.34	871.84	0.00	15	-	6	-	-	-	-	6	4

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
22-Ti- 51	3.48000E+02	868.93	364.55	0.00	3	2	-	-	-	-	-	6	3
23-V - 48	1.38015E+06	149.28	2915.94	0.00	9	-	6	-	-	-	-	3	4
23-V - 49	2.85120E+07	3.58	0.95	0.00	-	-	1	-	-	-	-	3	3
23-V - 52	2.24700E+02	1064.34	1448.36	0.00	14	8	-	-	-	-	-	15	3
23-V - 53	9.72000E+01	1005.11	1041.59	0.00	7	3	-	-	-	-	-	-	-
23-V - 54	4.98000E+01	1357.52	4097.54	0.00	24	8	-	-	-	-	-	-	-
24-Cr- 49	2.51400E+03	596.49	1047.24	0.00	12	-	8	-	-	-	-	12	4
24-Cr- 51	2.39380E+06	3.85	32.75	0.00	1	-	2	-	-	-	-	6	3
24-Cr- 55	2.12400E+02	1096.51	4.24	0.00	7	5	-	-	-	-	-	6	3
25-Mn- 53	1.16132E+14	4.00	1.42	0.00	-	-	1	-	-	-	-	3	3
25-Mn- 54	2.69827E+07	4.21	836.04	0.00	1	-	1	-	-	-	-	9	6
25-Mn- 56	9.28440E+03	823.81	1700.66	0.00	10	7	-	-	-	-	-	-	-
25-Mn- 58	6.52000E+01	1711.42	2382.19	0.00	39	14	-	-	-	-	-	27	3
25-Mn- 58m	2.70000E+00	2828.39	120.07	0.00	9	4	-	-	-	-	-	9	3
26-Fe- 53	5.10600E+02	1106.98	1184.25	0.00	10	-	8	-	-	-	-	6	4
26-Fe- 53m	1.54800E+02	0.00	3034.68	0.00	6	-	-	-	-	-	-	-	-
26-Fe- 55	8.63136E+07	4.22	1.67	0.00	-	-	1	-	-	-	-	3	3
26-Fe- 59	3.84497E+06	117.89	1189.21	0.00	8	5	-	-	-	-	-	18	3
26-Fe- 60	4.73364E+13	87.67	0.00	0.00	-	1	-	-	-	-	-	-	-
26-Fe- 63	6.10000E+00	2604.28	317.73	0.00	19	14	-	-	-	-	-	21	3
27-Co- 55	6.31080E+04	436.58	2007.03	0.00	23	-	10	-	-	-	-	24	4
27-Co- 56	6.67526E+06	121.02	3589.76	0.00	45	-	13	-	-	-	-	30	4
27-Co- 57	2.34827E+07	20.01	123.99	0.00	10	-	2	-	-	-	-	33	3
27-Co- 58	6.12230E+06	34.31	976.20	0.00	3	-	3	-	-	-	-	12	4
27-Co- 58m	3.21840E+04	23.15	1.82	0.00	1	-	-	-	-	-	-	6	3

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
27-Co- 60	1.66363E+08	96.71	2503.95	0.00	6	3	-	-	-	-	-	15	3
27-Co- 60m	6.28200E+02	56.50	6.79	0.00	4	2	-	-	-	-	-	15	6
28-Ni- 57	1.28520E+05	162.12	1960.02	0.00	24	-	9	-	-	-	-	18	4
28-Ni- 59	2.39838E+12	4.62	2.54	0.00	-	-	1	-	-	-	-	3	4
28-Ni- 63	3.12420E+09	17.14	0.00	0.00	-	1	-	-	-	-	-	-	-
28-Ni- 65	9.07200E+03	629.70	549.93	0.00	10	5	-	-	-	-	-	18	3
28-Ni- 66	1.95840E+05	65.24	0.00	0.00	-	1	-	-	-	-	-	-	-
28-Ni- 67	2.10000E+01	1523.24	50.25	0.00	7	6	-	-	-	-	-	-	-
29-Cu- 62	5.85000E+02	1282.90	1011.69	0.00	16	-	10	-	-	-	-	3	4
29-Cu- 64	4.57272E+04	125.75	190.56	0.00	1	1	2	-	-	-	-	3	4
29-Cu- 66	3.06000E+02	1070.64	81.86	0.00	3	4	-	-	-	-	-	-	-
29-Cu- 67	2.22840E+05	155.67	115.41	0.00	6	4	-	-	-	-	-	21	3
30-Zn- 63	2.30400E+03	916.73	1104.23	0.00	64	-	20	-	-	-	-	33	4
30-Zn- 65	2.11041E+07	6.98	582.52	0.00	3	-	2	-	-	-	-	6	4
30-Zn- 69	3.38400E+03	322.90	0.01	0.00	2	3	-	-	-	-	-	9	3
30-Zn- 69m	4.96080E+04	22.38	416.43	0.00	2	1	-	-	-	-	-	12	6
31-Ga- 70	1.26840E+03	640.49	9.18	0.00	3	3	1	-	-	-	-	12	8
31-Ga- 77	1.30000E+01	2111.68	457.02	0.00	14	9	-	-	-	-	-	21	5
32-Ge- 71	9.87552E+05	5.14	4.2	0.00	-	-	1	-	-	-	-	3	3
32-Ge- 71m	2.04000E-02	33.27	165.17	0.00	2	-	-	-	-	-	-	9	5
32-Ge- 73m	5.00000E-01	55.61	11.35	0.00	2	-	-	-	-	-	-	9	5
32-Ge- 75	4.96680E+03	419.78	34.73	0.00	11	5	-	-	-	-	-	18	5
32-Ge- 75m	4.80000E+01	81.87	58.06	0.00	14	1	-	-	-	-	-	48	10
32-Ge- 80	2.70000E+01	949.23	342.75	0.00	17	9	-	-	-	-	-	33	5
33-As- 73	6.93792E+06	5.23	4.76	0.00	-	-	1	-	-	-	-	3	5

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
33-As- 74	1.53619E+06	268.31	759.66	0.00	14	3	6	-	-	-	-	15	11
33-As- 76	9.43920E+04	1063.82	419.75	0.00	61	22	-	-	-	-	-	69	5
33-As- 82	2.00000E+01	3156.07	343.10	0.00	17	13	-	-	-	-	-	9	5
33-As- 82m	1.36000E+01	2037.24	2969.60	0.00	13	6	-	-	-	-	-	15	5
33-As- 85	2.04000E+00	3380.98	358.54	151.84	10	14	-	-	11	-	-	24	5
34-Se- 75	1.03369E+07	14.65	390.20	0.00	20	-	9	-	-	-	-	36	5
34-Se- 77m	1.75500E+01	73.28	88.81	0.00	1	-	-	-	-	-	-	6	5
34-Se- 79	1.18970E+13	52.55	0.00	0.00	-	1	-	-	-	-	-	-	-
34-Se- 79m	2.34000E+02	81.87	13.96	0.00	1	1	-	-	-	-	-	6	5
34-Se- 81	1.10340E+03	609.06	8.55	0.00	11	7	-	-	-	-	-	30	5
34-Se- 81m	3.43680E+03	85.40	18.03	0.00	8	2	-	-	-	-	-	30	10
35-Br- 72	7.86000E+01	2716.91	2921.83	0.00	35	-	13	-	-	-	-	57	6
35-Br- 72m	1.06000E+01	50.88	50.00	0.00	1	-	-	-	-	-	-	6	5
35-Br- 79m	4.88000E+00	50.00	157.16	0.00	1	-	-	-	-	-	-	6	5
35-Br- 80	1.05600E+03	724.04	77.00	0.00	6	4	3	-	-	-	-	24	12
35-Br- 80m	1.58760E+04	61.76	24.26	0.00	2	-	-	-	-	-	-	9	5
35-Br- 82	1.27152E+05	142.69	2638.03	0.00	34	6	-	-	-	-	-	60	6
35-Br- 82m	3.65400E+02	70.09	8.18	0.00	26	11	-	-	-	-	-	33	11
35-Br- 87	5.57000E+01	1576.66	3089.26	3.78	374	181	-	-	24	-	-	51	6
35-Br- 88	1.65000E+01	2393.53	3112.18	8.07	167	66	-	-	2	-	-	75	6
35-Br- 89	4.37000E+00	2572.12	1711.12	6.48	116	60	-	-	5	-	-	27	6
35-Br- 90	1.90000E+00	3290.29	1537.77	21.91	75	47	-	-	6	-	-	12	6
35-Br- 91	5.38000E-01	3908.96	451.19	10.00	4	6	-	-	1	-	-	15	6
36-Kr- 79	1.26144E+05	24.63	257.77	0.00	41	-	11	-	-	-	-	57	6
36-Kr- 79m	5.00000E+01	90.06	39.80	0.00	1	-	-	-	-	-	-	6	6

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
36-Kr- 81	6.62710E+12	5.39	7.37	0.00	1	-	2	-	-	-	-	6	5
36-Kr- 81m	1.32000E+01	58.77	131.72	0.00	1	-	1	-	-	-	-	9	11
36-Kr- 83m	6.58800E+03	39.32	2.44	0.00	2	-	-	-	-	-	-	8	6
36-Kr- 85	3.38602E+08	250.65	2.23	0.00	3	2	-	-	-	-	-	12	6
36-Kr- 85m	1.61280E+04	255.51	157.18	0.00	7	3	-	-	-	-	-	27	12
37-Rb- 83	7.44768E+06	8.64	496.07	0.00	11	-	6	-	-	-	-	35	6
37-Rb- 84	2.89440E+06	144.04	887.23	0.00	3	1	3	-	-	-	-	3	7
37-Rb- 84m	1.22400E+03	80.18	382.88	0.00	3	-	-	-	-	-	-	12	6
37-Rb- 86	1.60963E+06	665.79	96.75	0.00	1	2	1	-	-	-	-	3	6
37-Rb- 86m	6.10000E+01	9.96	546.02	0.00	1	-	-	-	-	-	-	6	6
37-Rb- 89	9.24000E+02	929.24	2234.21	0.00	62	22	-	-	-	-	-	114	6
37-Rb- 93	5.80000E+00	2117.68	2602.36	4.15	272	92	-	-	27	-	-	48	6
37-Rb- 94	2.70200E+00	3101.54	2747.43	10.05	161	87	-	-	8	-	-	72	6
37-Rb- 95	3.81000E-01	2828.94	2642.12	7.85	252	88	-	-	15	-	-	60	6
38-Sr- 83	1.16676E+05	148.99	776.22	0.00	120	-	23	-	-	-	-	122	7
38-Sr- 83m	4.95000E+00	31.17	228.09	0.00	1	-	-	-	-	-	-	6	6
38-Sr- 85	5.60295E+06	9.16	518.50	0.00	7	-	3	-	-	-	-	15	6
38-Sr- 85m	4.05660E+03	13.25	215.91	0.00	11	-	4	-	-	-	-	26	12
38-Sr- 87m	1.01376E+04	66.56	320.89	0.00	1	-	1	-	-	-	-	9	12
38-Sr- 89	4.36493E+06	582.30	1.29	0.00	-	2	-	-	-	-	-	-	-
38-Sr- 90	9.11002E+08	195.71	0.00	0.00	-	1	-	-	-	-	-	-	-
38-Sr- 92	9.75600E+03	179.90	1380.97	0.00	9	3	-	-	-	-	-	15	6
38-Sr- 94	7.53000E+01	833.17	1427.32	0.00	16	8	-	-	-	-	-	45	6
39-Y - 87	2.87280E+05	7.2	461.66	0.00	1	-	2	-	-	-	-	6	7
39-Y – 87m	4.81320E+04	78.65	308.17	0.00	1	-	1	-	-	-	-	9	13

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
39-Y - 88	9.21283E+06	6.77	2696.62	0.00	7	-	4	-	-	-	-	9	7
39-Y - 89m	1.60500E+01	7.71	901.36	0.00	1	-	-	-	-	-	-	6	6
39-Y - 90	2.30400E+05	930.62	2.87	0.00	3	3	-	-	-	-	-	3	-
39-Y – 90m	1.14840E+04	46.44	635.23	0.00	3	1	-	-	-	-	-	12	6
39-Y - 91	5.07168E+06	602.41	5.00	0.00	1	2	-	-	-	-	-	-	-
39-Y - 91m	2.98320E+03	27.99	527.61	0.00	1	-	-	-	-	-	-	6	6
39-Y - 96	5.37000E+00	3179.25	95.61	0.00	64	43	-	-	-	-	-	48	6
39-Y - 96m	9.62000E+00	1851.14	4486.45	0.00	59	15	-	-	-	-	-	117	6
39-Y - 97	3.75000E+00	2135.04	1845.99	0.12	25	11	-	-	1	-	-	30	6
39-Y - 97m	1.17000E+00	2317.49	2110.63	0.14	63	24	-	-	1	-	-	54	12
39-Y - 97n	1.42000E-01	120.75	2807.45	0.00	47	1	-	-	-	-	-	84	12
39-Y - 98	5.90000E-01	2779.90	2613.36	1.04	32	12	-	-	0c	-	-	54	6
39-Y - 98m	2.00000E+00	2788.18	3294.44	15.76	28	9	-	-	0c	-	-	54	6
39-Y - 99	1.47700E+00	2948.70	916.74	7.36	117	39	-	-	0c	-	-	213	6
39-Y -104	1.30000E-01	3494.00	3750.00	49.48	0c	0c	-	-	0c	-	-	-	-
39-Y -105	1.50000E-01	3325.00	2372.00	123.48	0c	0c	-	-	0c	-	-	-	-
40-Zr- 88	7.20576E+06	16.09	391.81	0.00	1	-	1	-	-	-	-	6	6
40-Zr- 89	2.82240E+05	92.78	253.88	0.00	4	-	5	-	-	-	-	3	7
40-Zr- 89m	2.50800E+02	32.74	638.03	0.00	2	-	2	-	-	-	-	9	13
40-Zr- 90m	8.08200E-01	16.2	2303.78	0.00	5	-	-	-	-	-	-	12	6
40-Zr- 93	4.82831E+13	19.13	0.00	0.00	-	2	-	-	-	-	-	-	-
40-Zr- 95	5.53219E+06	118.03	730.54	0.00	2	4	-	-	-	-	-	-	-
40-Zr- 99	2.20000E+00	1538.96	841.41	0.00	14	6	-	-	-	-	-	42	6
40-Zr-105	6.00000E-01	2662.00	1764.00	4.47	0c	0c	-	-	0c	-	-	-	-
40-Zr-106	9.00000E-01	2138.00	1091.00	5.80	0c	0c	-	-	0c	-	-	-	-

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
40-Zr-107	2.40000E-01	2982.00	2201.00	17.51	0c	0c	-	-	0c	-	-	-	-
41-Nb- 90	5.25240E+04	391.77	1960.33	0.00	33	-	9	-	-	-	-	45	7
41-Nb- 90m	1.88100E+01	42.3	82.38	0.00	2	-	-	-	-	-	-	7	6
41-Nb- 90n	6.22000E-03	38.7	218.55	0.00	1	-	-	-	-	-	-	6	6
41-Nb- 91	2.14592E+10	5.88	12.57	0.00	-	-	1	-	-	-	-	3	7
41-Nb- 91m	5.26176E+06	93.46	38.03	0.00	2	-	1	-	-	-	-	9	12
41-Nb- 92	1.10452E+15	7.93	1503.31	0.00	2	-	1	-	-	-	-	9	6
41-Nb- 92m	8.76960E+05	6.45	970.38	0.00	6	-	5	-	-	-	-	15	7
41-Nb- 93m	5.08896E+08	28.96	1.95	0.00	1	-	-	-	-	-	-	6	6
41-Nb- 94	6.30720E+11	168.27	1571.53	0.00	2	1	-	-	-	-	-	9	6
41-Nb- 94m	3.75600E+02	35.09	12.27	0.00	4	3	-	-	-	-	-	15	6
41-Nb- 95	3.02184E+06	44.60	764.35	0.00	3	3	-	-	-	-	-	12	6
41-Nb- 95m	3.11760E+05	173.65	71.68	0.00	5	4	-	-	-	-	-	12	12
41-Nb- 96	8.40600E+04	250.16	2445.75	0.00	39	8	-	-	-	-	-	93	6
41-Nb-100	1.40000E+00	2443.19	744.36	0.00	40	19	-	-	-	-	-	66	6
41-Nb-100m	2.90000E+00	2047.30	2064.43	0.00	22	7	-	-	-	-	-	69	6
41-Nb-109	1.90000E-01	3158.00	2263.00	68.40	0c	0c	-	-	0c	-	-	-	-
42-Mo- 93	9.50400E+10	5.65	10.94	0.00	-	-	2	-	-	-	-	3	6
42-Mo- 93m	2.46600E+04	107.21	2317.51	0.00	13	-	2	-	-	-	-	15	12
42-Mo- 99	2.37420E+05	392.36	146.76	0.00	35	12	-	-	-	-	-	42	6
42-Mo-103	6.79000E+01	1316.28	636.20	0.00	43	17	-	-	-	-	-	90	6
42-Mo-109	5.00000E-01	2675.00	1876.00	0.91	0c	0c	-	-	0c	-	-	-	-
42-Mo-111	5.00000E-01	3098.00	2413.00	3.57	0c	0c	-	-	0c	-	-	-	-
42-Mo-112	1.00000E+00	2552.00	1354.00	7.96	0c	0c	-	-	0c	-	-	-	-
43-Tc- 97	8.20498E+13	5.65	11.68	0.00	-	-	1	-	-	-	-	3	6

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
43-Tc- 97m	7.79328E+06	87.04	9.50	0.00	1	-	-	-	-	-	-	6	6
43-Tc- 99m	2.16360E+04	16.13	126.48	0.00	6	3	-	-	-	-	-	22	12
43-Tc-113	1.30000E-01	2732.00	1822.00	33.53	0c	0c	-	-	0c	-	-	-	-
43-Tc-114	2.00000E-01	3578.00	3257.00	32.88	0c	0c	-	-	0c	-	-	-	-
43-Tc-115	2.70000E-01	2995.00	2162.00	79.74	0c	0c	-	-	0c	-	-	-	-
43-Tc-116	1.20000E-01	3693.00	3495.00	71.73	0c	0c	-	-	0c	-	-	-	-
43-Tc-99	6.66812E+12	100.98	0.00	0.00	1	2	-	-	-	-	-	6	6
44-Ru-103	3.39206E+06	66.45	497.68	0.00	18	6	-	-	-	-	-	57	6
44-Ru-115	7.00000E-01	2538.00	1806.00	0.61	0c	0c	-	-	0c	-	-	-	-
44-Ru-116	1.70000E+00	1843.00	986.00	3.61	0c	0c	-	-	0c	-	-	-	-
44-Ru-117	3.40000E-01	2697.00	2026.00	8.31	0c	0c	-	-	0c	-	-	-	-
44-Ru-118	7.00000E-01	2094.00	1118.00	17.80	0c	0c	-	-	0c	-	-	-	-
44-Ru-119	1.90000E-01	2920.00	2311.00	20.66	0c	0c	-	-	0c	-	-	-	-
45-Rh-101	1.00982E+08	28.04	312.29	0.00	7	-	3	-	-	-	-	24	6
45-Rh-101m	3.74976E+05	20.17	305.56	0.00	10	-	2	-	-	-	-	36	12
45-Rh-102	9.15840E+07	12.16	2122.05	0.00	16	-	2	-	-	-	-	33	6
45-Rh-102m	1.79712E+07	173.60	493.17	0.00	30	2	7	-	-	-	-	57	19
45-Rh-103m	3.36690E+03	38.21	1.70	0.00	1	-	-	-	-	-	-	6	6
45-Rh-104	4.23000E+01	980.49	15.02	0.00	17	7	3	-	-	-	-	30	13
45-Rh-104m	2.60400E+02	86.20	45.52	0.00	22	7	-	-	-	-	-	27	12
45-Rh-105	1.27368E+05	153.21	78.04	0.00	5	4	-	-	-	-	-	18	6
45-Rh-105m	4.00000E+01	95.24	34.60	0.00	1	-	-	-	-	-	-	6	6
45-Rh-106	3.01000E+01	1401.28	218.09	0.00	87	36	-	-	-	-	-	48	6
45-Rh-106m	7.92000E+03	321.63	2759.22	0.00	40	5	-	-	-	-	-	84	6
45-Rh-110	2.85000E+01	1182.14	2553.61	0.00	25	5	-	-	-	-	-	45	6

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF^*	p	e^-	X-ray
45-Rh-110m	3.20000E+00	2266.23	335.96	0.00	8	6	-	-	-	-	-	27	6
45-Rh-111	1.20000E+01	1389.42	357.05	0.00	43	13	-	-	-	-	-	96	6
45-Rh-118	3.20000E-01	3094.00	2494.00	12.16	0c	0c	-	-	0c	-	-	-	-
45-Rh-120	1.70000E-01	3261.00	2837.00	29.19	0c	0c	-	-	0c	-	-	-	-
45-Rh-121	2.50000E-01	2671.00	1852.00	74.06	0c	0c	-	-	0c	-	-	-	-
46-Pd-103	1.46707E+06	5.88	14.68	0.00	8	-	4	-	-	-	-	27	6
46-Pd-107	2.05124E+14	9.40	0.00	0.00	-	1	-	-	-	-	-	-	-
46-Pd-107m	2.13000E+01	62.99	151.84	0.00	1	-	-	-	-	-	-	6	6
46-Pd-109	4.84560E+04	359.82	1.05	0.00	31	12	-	-	-	-	-	84	6
46-Pd-109m	2.82600E+02	77.49	111.43	0.00	1	-	-	-	-	-	-	6	6
46-Pd-112	7.30800E+04	89.90	5.25	0.00	1	1	-	-	-	-	-	4	2
46-Pd-113	9.10000E+01	1330.18	127.55	0.00	33	14	-	-	-	-	-	90	6
46-Pd-113m	3.00000E-01	59.42	21.40	0.00	1	-	-	-	-	-	-	6	6
46-Pd-121	6.00000E-01	2335.00	1638.00	0.75	0c	0c	-	-	0c	-	-	-	-
47-Ag-105	3.56832E+06	19.93	530.41	0.00	62	-	9	-	-	-	-	120	6
47-Ag-105m	4.33800E+02	25.34	1.22	0.00	20	-	9	-	-	-	-	34	8
47-Ag-106	1.44000E+03	503.52	705.98	0.00	36	1	17	-	-	-	-	30	7
47-Ag-106m	7.30944E+05	12.27	2754.44	0.00	57	-	5	-	-	-	-	87	6
47-Ag-107m	4.41000E+01	80.67	12.51	0.00	1	-	-	-	-	-	-	6	6
47-Ag-108	1.44000E+02	605.53	22.83	0.00	13	2	6	-	-	-	-	24	13
47-Ag-108m	1.31911E+10	16.04	1630.06	0.00	5	-	1	-	-	-	-	21	12
47-Ag-109m	3.97000E+01	76.74	11.30	0.00	1	-	-	-	-	-	-	6	6
47-Ag-110	2.47000E+01	1174.85	34.77	0.00	15	11	2	-	-	-	-	24	12
47-Ag-110m	2.15819E+07	69.02	2760.64	0.00	61	9	-	-	-	-	-	46	12
47-Ag-111	6.43680E+05	353.29	26.34	0.00	14	7	-	-	-	-	-	45	6

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
47-Ag-111m	6.48000E+01	56.01	6.88	0.00	11	4	-	-	-	-	-	39	12
47-Ag-114	4.70000E+00	2096.51	271.79	0.00	43	26	-	-	-	-	-	36	6
47-Ag-114m	1.50000E-03	101.88	97.12	0.00	4	-	-	-	-	-	-	15	6
47-Ag-115	1.23000E+03	779.22	1132.27	0.00	145	44	-	-	-	-	-	93	6
47-Ag-115m	1.86000E+01	844.05	454.99	0.00	25	10	-	-	-	-	-	66	12
48-Cd-107	2.34720E+04	6.27	21.24	0.00	35	-	12	-	-	-	-	81	7
48-Cd-109	3.99686E+07	5.71	15.15	0.00	-	-	1	-	-	-	-	3	6
48-Cd-111m	2.91240E+03	104.88	291.67	0.00	2	-	-	-	-	-	-	9	6
48-Cd-113	2.46144E+23	92.59	0.00	0.00	-	1	-	-	-	-	-	-	-
48-Cd-113m	4.60731E+08	184.49	0.07	0.00	1	1	-	-	-	-	-	6	6
48-Cd-115	1.92240E+05	317.15	193.34	0.00	16	7	-	-	-	-	-	33	6
48-Cd-115m	3.85344E+06	601.87	34.26	0.00	26	8	-	-	-	-	-	57	6
49-In-111	2.42326E+05	33.49	406.47	0.00	2	-	2	-	-	-	-	9	6
49-In-111m	4.74000E+02	67.84	469.64	0.00	1	-	-	-	-	-	-	6	6
49-In-112	8.82000E+02	245.21	290.19	0.00	16	1	9	-	-	-	-	30	7
49-In-112m	1.24200E+03	122.20	34.56	0.00	1	-	-	-	-	-	-	6	6
49-In-113m	5.96880E+03	131.33	260.35	0.00	1	-	-	-	-	-	-	6	6
49-In-114	7.19000E+01	769.23	4.37	0.00	3	2	2	-	-	-	-	3	7
49-In-114m	4.32000E+06	140.90	88.99	0.00	3	-	1	-	-	-	-	9	12
49-In-114n	4.30000E-02	33.96	277.66	0.00	1	-	-	-	-	-	-	6	6
49-In-115	1.39169E+22	207.88	0.00	0.00	-	1	-	-	-	-	-	-	-
49-In-115m	1.61496E+04	170.99	162.50	0.00	2	2	-	-	-	-	-	12	12
49-In-116	1.42000E+01	1356.65	5.27	0.00	11	8	-	-	-	-	-	21	6
49-In-116m	3.27600E+03	312.60	2490.78	0.00	40	7	-	-	-	-	-	114	6
49-In-116n	2.17000E+00	94.12	68.17	0.00	1	-	-	-	-	-	-	6	6

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF^*	p	e^-	X-ray
50-Sn-110	1.47600E+04	14.17	290.43	0.00	1	-	1	-	-	-	-	6	6
50-Sn-113	9.94378E+06	6.27	23.25	0.00	3	-	3	-	-	-	-	6	6
50-Sn-113m	1.25400E+03	58.58	14.48	0.00	1	-	1	-	-	-	-	9	12
50-Sn-117m	1.17504E+06	158.24	156.34	0.00	3	-	-	-	-	-	-	12	6
50-Sn-119m	2.53152E+07	78.26	11.36	0.00	2	-	-	-	-	-	-	8	6
50-Sn-121	9.71640E+04	115.89	0.00	0.00	-	1	-	-	-	-	-	-	-
50-Sn-121m	1.38535E+09	35.49	5.11	0.00	2	1	-	-	-	-	-	10	8
50-Sn-123	1.11629E+07	519.90	8.00	0.00	9	6	-	-	-	-	-	6	6
50-Sn-123m	2.40600E+03	475.46	141.20	0.00	5	3	-	-	-	-	-	6	6
50-Sn-125	8.32896E+05	805.01	316.10	0.00	49	15	-	-	-	-	-	60	6
50-Sn-125m	5.71200E+02	796.81	347.03	0.00	23	8	-	-	-	-	-	21	6
50-Sn-126	7.63694E+12	108.99	56.24	0.00	6	1	-	-	-	-	-	19	6
50-Sn-129	1.33800E+02	1097.58	1350.01	0.00	70	31	-	-	-	-	-	99	6
50-Sn-129m	4.32000E+02	705.53	1707.46	0.00	81	32	-	-	-	-	-	137	6
50-Sn-130	2.23800E+02	462.10	937.55	0.00	33	9	-	-	-	-	-	42	6
50-Sn-130m	1.02000E+02	1388.46	813.03	0.00	93	48	-	-	-	-	-	51	6
51-Sb-119	1.37880E+05	25.97	23.42	0.00	1	-	1	-	-	-	-	5	6
51-Sb-120	9.54000E+02	306.76	460.03	0.00	3	-	4	-	-	-	-	12	7
51-Sb-120m	4.97664E+05	45.05	2462.26	0.00	5	-	1	-	-	-	-	15	6
51-Sb-122	2.32920E+05	564.67	437.88	0.00	8	6	2	-	-	-	-	3	7
51-Sb-122m	2.51400E+02	93.06	70.53	0.00	3	-	-	-	-	-	-	11	6
51-Sb-124	5.20474E+06	381.74	1863.29	0.00	66	21	-	-	-	-	-	45	6
51-Sb-124m	9.30000E+01	114.07	437.54	0.00	5	3	-	-	-	-	-	16	8
51-Sb-124n	1.21200E+03	25.77	0.34	0.00	1	-	-	-	-	-	-	4	2
51-Sb-125	8.70653E+07	101.08	430.25	0.00	24	8	-	-	-	-	-	74	6

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
51-Sb-126	1.07222E+06	332.68	2752.52	0.00	27	14	-	-	-	-	-	84	6
51-Sb-126m	1.14600E+03	624.77	1575.98	0.00	9	4	-	-	-	-	-	31	8
51-Sb-126n	1.10000E+01	22.44	0.38	0.00	1	-	-	-	-	-	-	4	2
51-Sb-127	3.31776E+05	314.67	658.38	0.00	36	15	-	-	-	-	-	96	6
51-Sb-129	1.56960E+04	354.83	1380.09	0.00	70	30	-	-	-	-	-	48	6
51-Sb-129m	1.06200E+03	998.86	1477.98	0.00	37	8	-	-	-	-	-	42	12
51-Sb-135	1.74000E+00	2966.53	688.10	177.09	41	26	-	-	8	-	-	51	6
51-Sb-141	3.00000E-01	3511.07	3275.00	85.00	-	-	-	-	-	-	-	-	-
52-Te-121	1.65542E+06	9.84	577.47	0.00	5	-	2	-	-	-	-	18	6
52-Te-121m	1.33056E+07	80.09	216.95	0.00	12	-	6	-	-	-	-	42	13
52-Te-125m	5.01120E+06	108.78	36.00	0.00	3	-	-	-	-	-	-	12	6
52-Te-127	3.36600E+04	224.40	4.85	0.00	9	5	-	-	-	-	-	30	6
52-Te-127m	9.41760E+06	82.14	11.58	0.00	6	4	-	-	-	-	-	24	12
52-Te-129	4.17600E+03	543.03	60.45	0.00	58	11	-	-	-	-	-	71	6
52-Te-129m	2.92032E+06	240.18	38.94	0.00	40	9	-	-	-	-	-	65	12
52-Te-132	2.79072E+05	103.13	233.69	0.00	4	1	-	-	-	-	-	15	6
53-I -125	5.13475E+06	19.22	42.44	0.00	1	-	1	-	-	-	-	6	6
53-I -126	1.12147E+06	143.82	435.63	0.00	10	3	6	-	-	-	-	21	13
53-I -132	8.21880E+03	489.82	2255.72	0.00	165	34	-	-	-	-	-	282	6
53-I -132m	4.98000E+03	162.74	344.82	0.00	9	4	-	-	-	-	-	29	12
53-I -137	2.45100E+01	1861.83	1219.64	39.38	272	178	-	-	38	-	-	102	6
53-I -138	6.46000E+00	2720.49	1324.93	5.29	100	54	-	-	9	-	-	39	6
53-I -139	2.30000E+00	2532.93	672.34	11.12	111	44	-	-	6	-	-	115	6
54-Xe-125	6.08400E+04	34.51	270.53	0.00	35	-	11	-	-	-	-	36	7
54-Xe-125m	5.60000E+01	136.39	116.06	0.00	2	-	-	-	-	-	-	9	6

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e-	X-ray
54-Xe-127	3.14842E+06	32.50	280.66	0.00	6	-	3	-	-	-	-	21	6
54-Xe-127m	6.96000E+01	128.74	168.48	0.00	2	-	-	-	-	-	-	9	6
54-Xe-129m	7.66368E+05	184.17	51.70	0.00	2	-	-	-	-	-	-	9	6
54-Xe-131m	1.02557E+06	142.62	21.20	0.00	1	-	-	-	-	-	-	6	6
54-Xe-133	4.52995E+05	135.67	46.19	0.00	6	3	-	-	-	-	-	21	6
54-Xe-133m	1.89216E+05	192.38	40.79	0.00	1	-	-	-	-	-	-	6	6
55-Cs-123	3.54600E+02	942.45	1067.53	0.00	64	-	25	-	-	-	-	111	7
55-Cs-123m	1.70000E+00	112.15	44.13	0.00	4	-	-	-	-	-	-	14	6
55-Cs-129	1.15920E+05	17.42	283.21	0.00	30	-	8	-	-	-	-	87	6
55-Cs-131	8.37216E+05	6.37	23.12	0.00	-	-	1	-	-	-	-	3	6
55-Cs-132	5.64192E+05	14.11	715.25	0.00	13	2	4	-	-	-	-	45	13
55-Cs-134	6.51698E+07	163.39	1554.09	0.00	12	3	1	-	-	-	-	42	12
55-Cs-134m	1.04688E+04	111.78	27.08	0.00	3	-	-	-	-	-	-	11	6
55-Cs-135	7.57382E+13	66.86	0.00	0.00	-	1	-	-	-	-	-	-	-
55-Cs-135m	3.18000E+03	36.92	1596.54	0.00	2	-	-	-	-	-	-	9	6
55-Cs-136	1.12579E+06	141.89	2145.59	0.00	23	7	-	-	-	-	-	60	6
55-Cs-136m	1.90000E+01	616.67	616.67	0.00	-	-	-	-	-	-	-	-	-
55-Cs-137	9.52128E+08	186.54	0.04	0.00	-	2	-	-	-	-	-	-	-
56-Ba-126	6.00000E+03	18.13	565.11	0.00	90	-	26	-	-	-	-	114	7
56-Ba-129	8.56800E+03	127.27	466.47	0.00	94	-	8	-	-	-	-	209	7
56-Ba-129m	7.70400E+03	69.10	1207.46	0.00	95	-	12	-	-	-	-	206	7
56-Ba-131	9.97920E+05	46.25	459.52	0.00	62	-	12	-	-	-	-	177	7
56-Ba-131m	8.76000E+02	110.09	77.15	0.00	2	-	-	-	-	-	-	9	6
56-Ba-133	3.33677E+08	53.64	402.64	0.00	9	-	2	-	-	-	-	30	6
56-Ba-133m	1.37520E+05	221.61	66.91	0.00	4	-	1	-	-	-	-	17	12

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
56-Ba-137m	1.53180E+02	62.93	598.61	0.00	1	-	-	-	-	-	-	6	6
57-La-137	1.89346E+12	6.55	25.59	0.00	-	-	1	-	-	-	-	3	6
57-La-140	1.45026E+05	535.11	2312.59	0.00	39	18	-	-	-	-	-	74	6
57-La-152	2.80000E-01	2355.00	2885.00	23.97	0c	0c	-	-	0c	-	-	-	-
58-Ce-139	1.18930E+07	34.16	161.39	0.00	1	-	1	-	-	-	-	6	6
58-Ce-139m	5.61000E+01	55.09	699.12	0.00	1	-	-	-	-	-	-	6	6
58-Ce-145	1.77000E+02	762.59	601.03	0.00	88	22	-	-	-	-	-	153	6
58-Ce-147	5.70000E+01	1282.00	174.16	0.00	50	20	-	-	-	-	-	147	6
58-Ce-149	5.30000E+00	1818.17	84.56	0.00	21	12	-	-	-	-	-	57	6
58-Ce-153	1.50000E+00	1680.00	1125.00	1.57	0c	0c	-	-	0c	-	-	-	-
58-Ce-154	2.00000E+00	1694.00	958.70	1.62	0c	0c	-	-	0c	-	-	-	-
58-Ce-158	1.00000E+00	2441.75	2277.00	1.70	-	-	-	-	-	-	-	-	-
59-Pr-143	1.17158E+06	314.60	0.00	0.00	1	2	-	-	-	-	-	3	-
59-Pr-144	1.03680E+03	1200.64	33.76	0.00	21	10	-	-	-	-	-	27	6
59-Pr-144m	4.14000E+02	47.17	13.66	0.00	8	3	-	-	-	-	-	21	12
59-Pr-150	6.10000E+00	2230.23	554.20	0.00	41	23	-	-	-	-	-	75	6
59-Pr-156	5.00000E-01	2149.00	2688.00	8.93	0c	0c	-	-	0c	-	-	-	-
59-Pr-157	3.00000E-01	2387.00	1881.00	23.72	0c	0c	-	-	0c	-	-	-	-
60-Nd-140	2.91168E+05	6.73	27.73	0.00	-	-	1	-	-	-	-	3	6
60-Nd-147	9.52128E+05	270.60	138.13	0.00	14	6	-	-	-	-	-	39	6
60-Nd-157	2.50000E+00	1668.00	1140.00	0.00	0c	0c	-	-	-	-	-	-	-
60-Nd-158	7.00000E-01	1589.00	923.90	0.01	0c	0c	-	-	0c	-	-	-	-
60-Nd-159	5.00000E-01	2063.00	1666.00	0.51	0c	0c	-	-	0c	-	-	-	-
60-Nd-160	3.00000E-01	2100.00	1206.00	2.49	0c	0c	-	-	0c	-	-	-	-
61-Pm-143	2.29824E+07	8.11	315.82	0.00	1	-	2	-	-	-	-	6	6

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
61-Pm-144	3.13632E+07	16.77	1555.59	0.00	12	-	4	-	-	-	-	30	6
61-Pm-145	5.58570E+08	12.20	31.53	0.00	2	-	3	1	-	-	-	9	6
61-Pm-146	1.74528E+08	94.41	754.29	0.00	6	2	3	-	-	-	-	24	12
61-Pm-147	8.27440E+07	61.76	0.00	0.00	3	3	-	-	-	-	-	12	6
61-Pm-148	4.63795E+05	726.30	576.49	0.00	20	10	-	-	-	-	-	30	6
61-Pm-148m	3.54672E+06	171.05	1983.64	0.00	23	4	-	-	-	-	-	72	12
61-Pm-149	1.91088E+05	366.77	12.70	0.00	44	15	-	-	-	-	-	119	6
61-Pm-151	1.01160E+05	303.20	324.16	0.00	262	33	-	-	-	-	-	727	6
61-Pm-152	2.47200E+02	1391.25	147.10	0.00	92	24	-	-	-	-	-	162	6
61-Pm-152m	4.50000E+02	900.26	1501.81	0.00	83	19	-	-	-	-	-	144	6
61-Pm-152n	8.64000E+02	728.41	2160.79	0.00	56	1	-	-	-	-	-	153	6
61-Pm-155	4.15000E+01	1061.08	561.66	0.00	5	37	-	-	-	-	-	18	6
61-Pm-159	3.00000E+00	1782.00	1160.00	0.02	0c	0c	-	-	0c	-	-	-	-
61-Pm-160	2.00000E+00	1969.00	2500.00	0.55	0c	0c	-	-	0c	-	-	-	-
62-Sm-145	2.93760E+07	29.50	62.99	0.00	3	-	3	-	-	-	-	6	6
62-Sm-146	3.15576E+15	0.00	0.00	2570.51	-	-	-	1	-	-	-	-	-
62-Sm-147	3.34511E+18	0.00	0.00	2310.65	-	-	-	1	-	-	-	-	-
62-Sm-151	2.84018E+09	19.87	0.01	0.00	1	2	-	-	-	-	-	4	2
62-Sm-153	1.66680E+05	268.30	62.82	0.00	58	15	-	-	-	-	-	76	6
63-Eu-149	8.04384E+06	24.14	66.02	0.00	27	-	10	-	-	-	-	77	6
63-Eu-150	1.14739E+09	27.21	1528.02	0.00	122	-	23	-	-	-	-	354	7
63-Eu-150m	4.60800E+04	307.29	50.22	0.00	20	1	9	-	-	-	-	57	7
63-Eu-152	4.26730E+08	129.10	1164.20	0.00	130	14	17	-	-	-	-	252	13
63-Eu-152m	3.33900E+04	501.95	311.09	0.00	59	7	8	-	-	-	-	96	13
63-Eu-152n	5.76000E+03	72.26	75.51	0.00	5	-	-	-	-	-	-	15	6

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
63-Eu-154	2.71166E+08	274.46	1245.26	0.00	139	25	2	-	-	-	-	201	12
63-Eu-154m	2.78400E+03	82.50	74.36	0.00	16	-	-	-	-	-	-	36	6
63-Eu-155	1.52928E+08	66.56	64.16	0.00	12	6	-	-	-	-	-	33	6
63-Eu-156	1.31328E+06	447.83	1283.21	0.00	96	21	-	-	-	-	-	189	6
64-Gd-150	5.74348E+13	0.00	0.00	2796.67	-	-	-	1	-	-	-	-	-
64-Gd-151	1.07136E+07	38.83	70.40	0.00	27	-	12	1	-	-	-	83	6
64-Gd-153	2.07792E+07	43.73	106.65	0.00	16	-	6	-	-	-	-	49	6
64-Gd-163	6.80000E+01	1064.29	490.40	0.00	19	7	-	-	-	-	-	41	6
65-Tb-146	8.00000E+00	2994.34	1365.81	0.00	3	-	3	-	-	-	-	9	7
65-Tb-146m	2.40000E+01	1454.43	4097.18	0.00	16	-	10	-	-	-	-	21	7
65-Tb-156	4.46688E+05	84.60	1935.37	0.00	111	-	20	-	-	-	-	201	6
65-Tb-156m	8.78400E+04	22.06	37.59	0.00	2	-	-	-	-	-	-	6	2
65-Tb-156n	1.83600E+04	84.06	4.74	0.00	1	-	1	-	-	-	-	9	13
65-Tb-157	3.12420E+09	5.70	10.39	0.00	1	-	2	-	-	-	-	6	6
65-Tb-158	5.68025E+09	111.73	813.70	0.00	14	2	7	-	-	-	-	48	13
65-Tb-158m	1.08000E+01	85.93	24.20	0.00	1	-	-	-	-	-	-	6	6
65-Tb-160	6.24672E+06	257.28	1129.73	0.00	41	13	-	-	-	-	-	108	6
65-Tb-161	5.95296E+05	200.74	33.76	0.00	37	9	-	-	-	-	-	109	6
66-Dy-157	2.93040E+04	13.29	350.36	0.00	26	-	11	-	-	-	-	66	6
66-Dy-159	1.24762E+07	12.82	45.51	0.00	9	-	5	-	-	-	-	30	6
66-Dy-166	2.93760E+05	157.86	41.87	0.00	7	4	-	-	-	-	-	22	6
67-Ho-160	1.51800E+03	70.34	1713.47	0.00	82	-	23	-	-	-	-	144	7
67-Ho-160m	1.80000E+04	81.67	649.78	0.00	166	-	46	-	-	-	-	90	13
67-Ho-160n	2.90000E+00	93.88	105.68	0.00	5	-	-	-	-	-	-	15	6
67-Ho-161	8.92800E+03	33.44	58.17	0.00	51	-	12	-	-	-	-	151	6

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
67-Ho-161m	6.77000E+00	107.19	103.68	0.00	1	-	-	-	-	-	-	6	6
67-Ho-163	1.44218E+11	2.65	0.00	0.00	-	-	1	-	-	-	-	-	-
67-Ho-163m	1.10000E+00	61.24	236.53	0.00	1	-	-	-	-	-	-	6	6
67-Ho-164	1.71600E+03	184.26	28.16	0.00	4	2	3	-	-	-	-	18	12
67-Ho-164m	2.25600E+03	91.90	48.03	0.00	4	-	-	-	-	-	-	13	6
67-Ho-170	1.66800E+02	836.08	1834.58	0.00	43	11	-	-	-	-	-	89	6
67-Ho-170m	4.30000E+01	1365.31	679.36	0.00	31	22	-	-	-	-	-	24	6
68-Er-167m	2.27000E+00	110.06	97.59	0.00	1	-	-	-	-	-	-	6	6
68-Er-172	1.77480E+05	128.72	515.68	0.00	44	8	-	-	-	-	-	131	6
69-Tm-167	7.98854E+05	21.56	51.62	0.00	9	-	4	-	-	-	-	28	6
69-Tm-168	7.77600E+06	83.08	1210.45	0.00	72	1	17	-	-	-	-	174	13
69-Tm-170	1.11110E+07	327.54	4.15	0.00	2	2	2	-	-	-	-	12	12
69-Tm-171	6.04800E+07	25.56	0.68	0.00	1	2	-	-	-	-	-	6	6
69-Tm-172	2.28960E+05	527.71	480.50	0.00	50	16	-	-	-	-	-	69	6
70-Yb-175	3.61584E+05	121.64	79.94	0.00	6	3	-	-	-	-	-	21	6
70-Yb-176m	1.14000E+01	144.56	905.32	0.00	5	-	-	-	-	-	-	18	6
71-Lu-171	7.12800E+05	88.33	641.30	0.00	90	-	23	-	-	-	-	207	7
71-Lu-171m	7.80000E+01	69.44	1.79	0.00	1	-	-	-	-	-	-	6	6
71-Lu-172	5.78880E+05	111.38	1955.21	0.00	197	-	29	-	-	-	-	534	7
71-Lu-172m	2.22000E+02	40.20	1.67	0.00	1	-	-	-	-	-	-	4	2
71-Lu-173	4.21632E+07	46.18	170.16	0.00	19	-	6	-	-	-	-	59	6
71-Lu-174	1.12320E+08	44.82	116.67	0.00	5	-	3	-	-	-	-	18	7
71-Lu-174m	1.22688E+07	116.85	61.67	0.00	12	-	1	-	-	-	-	40	12
71-Lu-177	5.78880E+05	147.42	36.86	0.00	6	4	-	-	-	-	-	21	6
71-Lu-177m	1.38499E+07	82.08	167.77	0.00	10	1	-	-	-	-	-	33	6

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
72-Hf-173	8.60400E+04	52.05	396.61	0.00	79	-	20	-	-	-	-	167	7
72-Hf-174	6.31152E+22	0.00	0.00	2503.61	-	-	-	1	-	-	-	-	-
72-Hf-175	6.04800E+06	45.51	362.99	0.00	8	-	4	-	-	-	-	27	6
72-Hf-177m	1.08000E+00	240.71	1068.02	0.00	39	-	-	-	-	-	-	118	6
72-Hf-177n	3.08400E+03	251.54	1177.27	0.00	10	-	-	-	-	-	-	27	6
72-Hf-178m	4.00000E+00	141.51	1005.89	0.00	5	-	-	-	-	-	-	18	6
72-Hf-178n	9.78286E+08	73.62	1223.12	0.00	11	-	-	-	-	-	-	35	6
72-Hf-179m	1.86700E+01	134.08	240.74	0.00	3	-	-	-	-	-	-	12	6
72-Hf-179n	2.16864E+06	186.34	919.03	0.00	13	-	-	-	-	-	-	41	6
72-Hf-180m	1.98000E+04	148.58	992.43	0.00	7	2	-	-	-	-	-	26	12
72-Hf-181	3.66163E+06	204.39	530.53	0.00	10	2	-	-	-	-	-	29	6
73-Ta-177	2.03040E+05	22.72	67.75	0.00	47	-	12	-	-	-	-	138	7
73-Ta-179	5.08032E+07	7.40	29.25	0.00	-	-	1	-	-	-	-	3	6
73-Ta-180	2.90880E+04	64.06	45.93	0.00	2	2	2	-	-	-	-	12	12
73-Ta-180m	5.68037E+22	125.85	562.52	0.00	6	1	1	-	-	-	-	24	12
73-Ta-182	9.91008E+06	216.34	1283.32	0.00	43	10	-	-	-	-	-	128	6
73-Ta-182m	2.83000E-01	14.32	1.92	0.00	1	-	-	-	-	-	-	4	2
73-Ta-182n	9.50400E+02	244.38	254.64	0.00	5	-	-	-	-	-	-	18	6
73-Ta-183	4.39776E+05	349.36	286.64	0.00	31	4	-	-	-	-	-	93	6
74-W -176	9.00000E+03	57.30	171.53	0.00	6	-	3	-	-	-	-	18	6
74-W -178	1.86624E+06	6.99	19.16	0.00	-	-	1	-	-	-	-	3	6
74-W -181	1.04527E+07	12.68	41.21	0.00	3	-	4	-	-	-	-	10	6
74-W -183m	5.25000E+00	183.99	125.39	0.00	6	-	-	-	-	-	-	19	6
74-W -185	6.48864E+06	126.80	0.05	0.00	1	2	-	-	-	-	-	6	6
74-W -185m	1.00000E+02	171.99	25.74	0.00	14	-	-	-	-	-	-	38	6

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
74-W -187	8.58600E+04	301.26	442.10	0.00	48	17	-	-	-	-	-	118	6
74-W -188	6.02899E+06	99.59	1.91	0.00	6	4	-	-	-	-	-	20	6
75-Re-183	6.04800E+06	107.43	159.25	0.00	28	-	9	-	-	-	-	84	6
75-Re-183m	1.03000E-03	316.99	1588.64	0.00	16	-	-	-	-	-	-	51	6
75-Re-184	3.05856E+06	54.72	905.64	0.00	30	-	9	-	-	-	-	90	7
75-Re-184m	1.45152E+07	140.48	390.15	0.00	36	-	1	-	-	-	-	112	12
75-Re-186	3.24000E+05	337.33	20.89	0.00	9	4	2	-	-	-	-	30	12
75-Re-186m	5.99582E+12	129.8	19.81	0.00	4	-	-	-	-	-	-	12	6
75-Re-191	5.82000E+02	726.98	2.23	0.00	-	1	-	-	-	-	-	-	-
75-Re-192	6.20000E+00	1637.85	159.06	0.00	5	4	-	-	-	-	-	18	6
76-Os-180	1.29000E+03	23.82	136.78	0.00	21	-	10	-	-	-	-	60	7
76-Os-185	8.10432E+06	18.33	719.03	0.00	16	-	6	-	-	-	-	50	6
76-Os-189m	2.09160E+04	28.71	2.18	0.00	1	-	-	-	-	-	-	4	2
76-Os-190m	5.94000E+02	116.85	1588.53	0.00	5	-	-	-	-	-	-	17	6
76-Os-191	1.32192E+06	37.52	0.00	0.00	-	1	-	-	-	-	-	-	-
76-Os-191m	4.71600E+04	66.58	7.81	0.00	1	-	-	-	-	-	-	6	6
76-Os-194	1.89342E+08	44.29	4.09	0.00	2	3	-	-	-	-	-	8	6
76-Os-195	3.90000E+02	715.26	142.23	0.00	17	6	-	-	-	-	-	44	6
76-Os-196	2.09400E+03	372.56	77.03	0.00	10	8	-	-	-	-	-	30	6
77-Ir-187	3.78000E+04	63.79	301.51	0.00	96	-	24	-	-	-	-	273	7
77-Ir-190	1.03680E+06	72.11	1478.08	0.00	63	-	10	-	-	-	-	132	7
77-Ir-190m	4.03200E+03	23.84	2.28	0.00	1	-	-	-	-	-	-	4	2
77-Ir-190n	1.11132E+04	28.88	58.87	0.00	6	-	1	-	-	-	-	21	12
77-Ir-191m	4.90000E+00	95.72	75.39	0.00	4	-	-	-	-	-	-	13	6
77-Ir-191n	5.50000E+00	45.76	1868.05	0.00	4	-	-	-	-	-	-	15	6

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
77-Ir-192	6.37822E+06	217.29	816.48	0.00	27	6	3	-	-	-	-	87	12
77-Ir-192m	8.64000E+01	54.43	2.44	0.00	4	3	-	-	-	-	-	16	8
77-Ir-192n	7.60522E+09	165.04	3.09	0.00	2	-	-	-	-	-	-	7	6
77-Ir-193m	9.10656E+05	77.70	2.59	0.00	1	-	-	-	-	-	-	6	6
77-Ir-197	3.48000E+02	733.37	223.79	0.00	40	23	-	-	-	-	-	91	6
77-Ir-197m	5.34000E+02	680.01	2.04	0.00	1	1	-	-	-	-	-	6	6
78-Pt-190	2.05120E+19	0.00	0.00	3251.51	-	-	-	1	-	-	-	-	-
78-Pt-193	1.57788E+09	7.86	33.78	0.00	-	-	1	-	-	-	-	3	6
78-Pt-193m	3.74976E+05	137.96	12.33	0.00	3	-	-	-	-	-	-	7	6
78-Pt-195m	3.54240E+05	182.26	76.47	0.00	9	-	-	-	-	-	-	27	6
78-Pt-197	7.16094E+04	254.43	24.38	0.00	3	3	-	-	-	-	-	11	6
78-Pt-197m	5.71800E+03	316.94	76.08	0.00	2	1	-	-	-	-	-	8	6
78-Pt-202	1.58400E+05	658.92	1.93	0.00	-	1	-	-	-	-	-	-	-
79-Au-192m	2.90000E-02	126.10	8.85	0.00	4	-	-	-	-	-	-	12	6
79-Au-192n	1.60000E-01	161.47	134.69	0.00	6	-	-	-	-	-	-	19	6
79-Au-195	1.60785E+07	48.79	86.33	0.00	5	-	5	-	-	-	-	17	6
79-Au-195m	3.05000E+01	115.53	203.01	0.00	5	-	-	-	-	-	-	16	6
79-Au-197m	7.74000E+00	183.82	225.44	0.00	5	-	-	-	-	-	-	17	6
79-Au-198	2.32788E+05	327.34	402.89	0.00	3	3	-	-	-	-	-	12	6
79-Au-198m	1.98720E+05	262.08	527.82	0.00	6	-	-	-	-	-	-	18	6
79-Au-199	2.71210E+05	145.08	96.07	0.00	3	3	-	-	-	-	-	11	6
80-Hg-190	1.20000E+03	68.07	204.38	0.00	25	-	14	-	-	-	-	76	7
80-Hg-194	1.40113E+10	7.34	14.68	0.00	-	-	1	-	-	-	-	3	6
80-Hg-197	2.32560E+05	69.15	73.51	0.00	3	-	3	-	-	-	-	11	6
80-Hg-197m	8.60400E+04	200.56	77.98	0.00	2	-	1	-	-	-	-	12	12

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
80-Hg-199m	2.52600E+03	347.70	184.57	0.00	4	-	-	-	-	-	-	15	6
80-Hg-203	4.02581E+06	99.11	237.74	0.00	1	1	-	-	-	-	-	6	6
80-Hg-205	3.12000E+02	536.24	6.89	0.00	13	7	-	-	-	-	-	24	6
81-Tl-193	1.30800E+03	94.34	555.90	0.00	50	-	26	-	-	-	-	87	7
81-Tl-193m	1.26600E+02	109.18	363.45	0.00	3	-	1	-	-	-	-	13	13
81-Tl-201	2.62742E+05	44.08	95.41	0.00	9	-	3	-	-	-	-	22	6
81-Tl-202	1.05754E+06	22.51	466.54	0.00	3	-	3	-	-	-	-	12	7
81-Tl-204	1.19603E+08	236.21	1.06	0.00	-	1	1	-	-	-	-	3	6
82-Pb-201	3.38400E+04	58.28	768.05	0.00	74	-	25	-	-	-	-	143	7
82-Pb-201m	6.10000E+01	262.19	366.14	0.00	1	-	-	-	-	-	-	6	7
82-Pb-202	1.67255E+12	9.28	69.97	0.00	-	-	1	-	-	-	-	3	6
82-Pb-202m	1.28520E+04	138.45	1975.52	0.00	22	-	3	-	-	-	-	72	13
82-Pb-203	1.86804E+05	52.33	315.18	0.00	3	-	2	-	-	-	-	12	6
82-Pb-203m	6.29000E+00	171.21	654.09	0.00	3	-	-	-	-	-	-	10	7
82-Pb-203n	4.80000E-01	216.40	1906.57	0.00	14	-	-	-	-	-	-	44	7
82-Pb-204	4.41806E+24	0.00	0.00	1971.69	-	-	-	1	-	-	-	-	-
82-Pb-204m	4.05000E+03	103.27	2080.67	0.00	6	-	-	-	-	-	-	21	7
82-Pb-205	4.82831E+14	8.95	59.29	0.00	-	-	1	-	-	-	-	3	6
83-Bi-207	1.00224E+09	118.46	1539.51	0.00	6	-	4	-	-	-	-	21	8
83-Bi-208	1.16132E+13	8.52	2657.34	0.00	1	-	1	-	-	-	-	3	7
84-Po-208	9.24638E+07	0.00	0.02	5215.29	8	-	1	2	-	-	-	28	14
86-Rn-223	1.45200E+03	624.91	330.14	0.00	294	60	-	-	-	-	-	270	7
90-Th-228	6.03590E+07	20.48	3.08	5497.53	14	-	-	9	-	-	-	43	7
90-Th-231	9.18720E+04	164.94	25.82	0.00	47	13	-	-	-	-	-	122	7
93-Np-239	2.03472E+05	262.84	182.19	0.00	33	8	-	-	-	-	-	89	7

Nuclide	$T_{1/2}$ (s)	Mean Decay Energies (keV)			Number of Spectral Lines								
		Light Particle	Electro-magnetic	Heavy Particle	γ	β^-	β^+	α	n	SF*	p	e^-	X-ray
95-Am-241	1.36581E+10	39.08	27.51	5557.44	185c	-	-	53	0c	0	-	372	7
95-Am-243	2.32416E+11	23.93	56.97	5358.99	18c	-	-	12	0c	0	-	46	7

* A zero in this column indicates the presence of spontaneous fission fragment data - no spectral data are specified (only mean energies) for the SF fragments in ENDF-6 format.

Table 3. Nuclides Evaluated in 2007/08

Nuclide	Half-life	Consistency (% Deviation)
21-Sc- 45m	0.325 (4) s	-0.0903
31-Ga- 70	21.14 (5) m	-0.0002
32-Ge- 71	11.43 (2) d	-0.0402
[32-Ge- 71m]	0.02040 (18) s	-0.0361
32-Ge- 75	82.78 (4) m	-0.0284
32-Ge- 75m	48.0 (9) s	-0.0330
34-Se- 79	3.77 (40) x 10^5 y	0.0000
39-Y - 90	64.00 (21) h	0.0089
39-Y – 90m	3.19 (6) h	-0.0020
[40-Zr- 90m]	0.8082 (20) s	-0.0421
41-Nb- 90	14.59 (5) h	-0.0108
41-Nb- 90m	18.81 (9) s	0.0185
[41-Nb- 90n]	0.00622 (8) s	0.0158
48-Cd-113	7.8 (3) x 10^{15} y	0.0000
48-Cd-113m	14.6 (1) y	0.0000
50-Sn-121	26.99 (10) h	0.0000
50-Sn-121m	43.9 (5) y	-0.0914
66-Dy-166	81.6 (2) h	0.0542
69-Tm-170	128.6 (3) d	0.0041
70-Yb-176m	11.4 (3) s	-0.0071
75-Re-184	35.4 (5) d	0.0468
76-Os-189m	5.81 (10) h	-0.2464
78-Pt-190	6.5 (3) x 10^{11} y	-0.0157

Radionuclides in parentheses have not been specifically requested, but have been included because they are related ground/metastable states or short-lived daughter nuclides.

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Appendix I
Comments from New Evaluations

Reproduced below are the comments associated with each of the nuclides evaluated in 2007/08. These cite a significant number of specific references by first-named author. However, these references are not listed in this report as they are too numerous for such an exercise, and the reader is referred to the Comments Section of the relevant ENDF-6 decay-data file of the radionuclide for their full details.

21-Sc- 45m

The half-life of 0.325(4) secs is based on the mean lifetime measurements of Holland et al (1964) and Blaugrund et al (1967). Further measurements are required to gain greater confidence in the recommended value.

A very simple IT decay scheme has been derived from the studies of Holland et al (1964), Blaugrund et al (1967) and Rust et al (1974). An absolute emission probability of 0.236(3)% for the 12.40-keV gamma ray was calculated from the 100% transition probability and the theoretical conversion coefficients of Kibedi et al (2005). Although in some doubt, the gamma transition type was assumed to be M2.

31-Ga- 70

The half-life of 21.14(5) mins is the weighted mean value of the measurements of Bunker et al (1957), Burmester (1975), and Schrewe and Schmidt-Ott (1977).

A simple decay scheme has been predominantly derived from the measurements of Schrewe and Schmidt-Ott (1977), and the E0 (1215.5-keV) gamma-transition studies of Alburger (1958). The beta branches to the 1215.54- and 1039.49-keV nuclear levels of Ge-70 of 0.0032(1) and 0.0036(2), respectively, and an EC branching fraction of 0.0041(5) directly to the ground state of Zn-70 were adopted from the studies of Schrewe and Schmidt-Ott; and these data were used in conjunction with the theoretical conversion coefficients derived from Kibedi et al (2005) to determine the absolute emission probabilities of the two major gamma rays (176.05 and 1039.49 keV). An E0 gamma transition also occurs between the 1215.54-keV nuclear level and ground state of Ge-70:

$$TP(1215.54\ keV) / TP(176.05\ keV) \sim 0.014,$$

as defined by Alburger, to give TP(1215.54-keV E0 transition) = 0.0045%. This low-intensity transition does not contribute significantly to the overall energy balance and consistency of the proposed decay scheme. Measurements of the absolute gamma-ray and conversion-electron emission probabilities are required to define the proposed decay scheme with greater confidence.

32-Ge- 71

The half-life of 11.43(2) days is the weighted mean value of the single measurement of Genz et al (1971) and the six sets of measurements of Hampel and Remsberg (1985). Further measurements are merited to confirm and fortify the existing data set.

A very simple decay scheme has been derived that consists of a single EC transition directly to the ground state of Ga-71. There is no evidence of any gamma-ray emissions.

32-Ge- 71m

The half-life of 20.40(18) msecs is the weighted mean of the measurements of Schardt and Goodman (1961), Morozov (1961), Morozov and Remaev (1962), Alexander and Brinckmann (1963), Meyers and Schats (1966), Rurarz et al (1970), Murray et al (1971), Goncharov et al (1972), Bunting and Kraushaar (1974), Garg and Khurana (1976), and Jones et al (1980), with the uncertainty increased to that of the lowest measured value. The extremely accurate value of 21.87(7) msecs determined by Brandstadter et al (1972) was set aside because the assignment of such a low uncertainty was judged as difficult to justify.

A two-gamma cascade was adopted for the IT decay scheme, as defined by Schardt and Goodman (1961), Morozov (1961), Murray et al (1971), and Bunting and Kraushaar (1974). Theoretical internal conversion coefficients were adopted from the derivations and interpolations of Kibedi et al (2005) in order to calculate the absolute gamma-ray emission probabilities of the 23.42-keV M2 and 174.949-keV E2 gamma transitions from their transition probabilities (each 100%).

32-Ge- 75

The recommended half-life of 82.78(4) mins is dominated by the measurement of Reynolds et al (1968); all other studies have significantly larger uncertainties of the order of 5%. Further measurements are required to gain confidence in the recommended value.

A reasonably consistent decay scheme can be constructed from the relative gamma-ray emission probabilities measured by Ng et al (1968), Venkataratnam and Lakshminarayana (1974), and Bhattacharyya et al (1979). Beta-particle emissions to the 400.658- and 279.543-keV nuclear levels of As-75 were assumed to be zero on the basis of spin and parity considerations. Population/depopulation considerations of the various nuclear levels resulted in minor adjustments to the relative emission probabilities of the 198.606-, 270.14-, 279.54- and 338.15-keV gamma rays, along with the introduction of an estimated relative emission probability for the extremely low intensity 80.937-keV gamma ray that is part of both the Ge-75m and Se-75 decay schemes (Bé et al (2007)). Theoretical internal conversion coefficients were adopted from the derivations and interpolations of Kibedi et al (2005). A normalization factor of 0.112(11) was calculated for the gamma-ray emission probabilities based on a value of 0.114(11) for the beta branch to the 264.658-keV nuclear level of As-75 as determined by Schardt and Welker (1955).

There are a number of relatively minor uncertainties within the detail of the proposed decay scheme (with respect to the balanced population/depopulation of the nuclear levels), and specific adjustments have been made to derive a complete and reasonably consistent data set. Further gamma-ray measurements are required to confirm, clarify and resolve various aspects of the decay scheme, particularly with respect to the determination of the absolute gamma-ray emission probabilities.

32-Ge- 75m

The recommended half-life of 48.0(9) secs is the weighted mean value of the measurements of Imanishi et al (1969), Meeker and Tucker (1970), Bunting and Kraushaar (1974), Chacko et al (1974), and Bhattacharyya et al (1976). However, there is a significant spread in this data set, and further measurements are required to gain greater confidence in the recommended value.

A reasonably consistent decay scheme can be constructed from the relative gamma-ray emission probabilities measured by Bhattacharyya et al (1976) and the equivalent evaluated decay scheme data of Se-75 (Bé et al (2007)). However, the existence of the 61.2- and 78.5-keV gamma rays within the IT decay mode and the associated 61.2-keV nuclear level of Ge-75 are questionable. Furthermore, various unobserved gamma transitions were introduced into the proposed decay scheme on the basis of their existence within the analysis of the equivalent Se-75 decay scheme (24.38-, 66.052-, 80.937-, 96.73-, 198.606-, 264.658- and 303.92-keV gamma rays); multipolarities for many of these transitions were taken from the same detailed evaluation (Bé et al (2007)). Theoretical internal conversion coefficients were adopted from the derivations and interpolations of Kibedi et al (2005). Finally, minor adjustments were made to the relative emission probabilities of the 78.5- and 279.542-keV gamma rays to achieve population-depopulation balances for specific nuclear levels.

Beta decay to the 303.92-, 279.54-, 264.66- and 198.606-keV nuclear levels and the ground state of As-75 were assumed to be zero on the basis of spin and parity considerations. Only a single beta-particle emission to the 400.657-keV nuclear level of As-75 has been assumed for the beta-decay mode. A normalization factor of 0.395(3) was calculated for the gamma-ray emission probabilities based on the above data and the proposed decay scheme – this value was determined from the summation to 100% of the transition probabilities of the 78.5- and 139.69-keV gamma transitions depopulating the 139.69-keV metastable state and the 96.73-, 121.115-, 136.00- and 400.657-keV gamma transitions depopulating the 400.657-keV nuclear level of As-75.

There are a significant number of relatively minor uncertainties within the detail of the proposed decay scheme (with respect to the balanced population/depopulation of the nuclear levels), and specific adjustments have been made to derive a complete and reasonably consistent data set. Further gamma-ray measurements are required to confirm, clarify and resolve various aspects of the decay scheme, particularly with respect to the determination of the absolute gamma-ray emission probabilities.

34-Se- 79

Se-79 undergoes beta decay directly to the ground state of Br-79 only, without emitting any gamma rays. Activity measurements were initially published in 1949, and cited by Singh and Viggars (1982) in determining an upper limit for the half-life of ≤ 6.5E+04 years. This upper limit was brought into question by Hermann because of inconsistencies in the measured and calculated fission yields of Se-79, and was modified by Singh (1993) to ≤ 6.5E+05 years.

Guo Jingru, Song-Sheng Jiang and co-workers have measured the half-life of Se-79 directly by means of radiochemical methods (Yu Runlan et al, and Li Chunsheng et al) and accelerator mass spectrometry (Song-Sheng Jiang et al (1996, 1997, 2001, 2002), and Ming He et al (2000, 2002)). Initially, Yu Runlan et al (1995) measured a half-life of 4.8(4)E+05 years, but somewhat later Li Chunseng et al (1997) determined a mean value of 1.13(17)E+06 years from three equivalent radiochemical measurements. Accelerator mass spectrometric measurements of the half-life from the same laboratory have varied between 1.1(2)E+06 years as determined by Song-Sheng Jiang et al (1997) and 2.95(38)E+05 years as reported by Song-Sheng Jiang et al (2001 and 2002). *Log ft* calculations undertaken at the same laboratory have also been used to determine an estimated half-life of 5.6E+05 years.

Bienvenu et al (2007) have undertaken a new measurement of the half-life by means of inductively coupled plasma mass spectrometry and liquid scintillation counting on a source purified from a nuclear reprocessing solution. A half-life value of 3.77(19)E+05 years was determined in this study that includes an extensive analysis of and correction for radioactive contaminants.

A rather disturbing discovery was noted when assembling and comparing the significant number of publications reporting Se-79 half-life measurements: papers published at almost the same time in Nucl. Instrum. Methods Phys. Res. by the same team of people using the same technique result in recommended half-life results that differed by over 5% (15 parts in 280) – 2.80(36)E+05 years by Ming He et al (2002), and 2.95(38)E+05 years by Song-Sheng Jiang et al (2002). Many changes have occurred in the data originating from Song-Sheng Jiang and co-workers over an eight-year period from 1995 to 2002. Under these difficult circumstances, the half-life value determined by Bienvenu et al (2007) has been adopted, with the uncertainty increased from 5% to 10% to give a recommended Se-79 half-life of 3.77(40)E+05 years. Further mass spectrometric studies are merited to address the existing uncertainty, and confirm the validity of the most recent measurement.

39-Y – 90

The half-life of 64.00(21) hours is the weighted mean value of the measurements of Volchok and Kulp (1955), Herrmann and Strassmann (1956), Peppard et al (1957), von Gunten et al (1963), Riehs (1966), Bienlein et al (1967), Lagoutine et al (1968), and Groll et al (1969).

A simple decay scheme has been predominantly derived from the measurements of Langhoff and Hennies (1961), Nessin et al (1962), Griffin (1976), and Zheltonozhskii et al (1991). The beta branches to the 2186.27- and 1760.71-keV nuclear levels of Zr-90 of 0.0000000113(6) and 0.000115(15), respectively, were adopted from these studies, and these data were used in conjunction with the theoretical conversion coefficients derived from Kibedi et al (2005) to determine the absolute emission probabilities of the 425.6- and 2186.27-keV gamma rays. An E0 gamma transition also occurs between the 1760.71-keV nuclear level and ground state of Zr-70 with a total transition probability of 0.0115(15)%. This low-intensity transition does not contribute significantly to the overall energy balance and consistency of the proposed decay scheme, and therefore was not included in the average energy calculation.

39-Y – 90m

The half-life of 3.19(6) hours is the weighted mean value of the measurements of Haskin and Vandenbosch (1961), Heath et al (1961), Carter-Waschek and Linder (1961), Abecasis et al (1962), Grench et al (1967) and Antony et al (1992).

A reasonably consistent decay scheme has been derived from the studies of Raman and Gove (1973), Hanser (1973), Kluge et al (1974), Griffin (1976), and Rao and Günther (1978). The small beta branch of 0.000021(2) directly to the 2319.00-keV nuclear level of Zr-90m was adopted from the measurements of Griffin. The emission probability ratio:

$$P_\gamma(681.67\ \text{keV})/P_\gamma(479.17\ \text{keV})$$

has been determined by Kluge et al, Griffin, and Rao and Günther, and a weighted mean value of 0.0035(3) was adopted in conjunction with the theoretical conversion coefficients derived from Kibedi et al (2005) to determine the absolute emission probabilities of the 202.50-, 479.17- and 681.67-keV gamma rays within the IT-decay mode. 100%M1, 100%M4 and 100%E5 multipolarities were adopted for the 202.50-, 479.17- and 681.67-keV gamma transitions, respectively. Measurements of the absolute gamma-ray and conversion-electron emission probabilities are required to define the proposed decay scheme with greater confidence.

40-Zr- 90m

The half-life of 0.8082(20) secs is the weighted mean value of the measurements of Campbell et al (1955), Wagner et al (1963), and Brandstädter et al (1972).

A relatively simple IT decay scheme has been derived. The absolute emission probabilities of the gamma rays were derived from the measurements of Pettersson et al (1968), Warburton and Alburger (1982), and Meyer (1990), after consideration of the transition probabilities and those components that arise directly from the EC decay of Nb-90 (for the 425.6- and 2186.27-keV gamma transitions (see also separate decay data file)). While the E3+M4 mixing ratio of the 132.73-keV gamma ray is important in the evolution of the decay scheme, this transition was judged to be 100% E3. Theoretical internal conversion coefficients were adopted from the derivations and interpolations of Kibedi et al (2005). The 1760.71-keV E0 gamma transition has a small overall transition probability of approximately 0.004%, and therefore was not included in the energy balance calculations.

41-Nb- 90

The half-life of 14.59(5) hours is the weighted mean value of the measurements of Diamond (1953), Ong Ping Hok (1954), Sheline (1957), and Pettersson et al (1968), with the uncertainty increased to the minimum measured value.

A relatively complex decay scheme can be constructed from the relative gamma-ray emission probabilities measured by Pettersson et al (1968), Warburton and Alburger (1982), and Meyer (1990). All observed gamma-ray transitions were placed in the proposed decay scheme, including the 2000.2-keV gamma ray that depopulates a tentative 4319.2-keV nuclear level and consequently populates the 2319.00-keV metastable state (Zr-90m, with a half-life of 0.8082(20) secs). The E2+M3 mixing ratio of the 141.19-keV gamma transition is particularly important in the evolution of a consistent decay scheme, and was estimated to be –0.105(40) from a population/depopulation balance of the 3448.23-keV nuclear level. Other mixed polarities for the 420.30-, 518.61- and 791.84-keV gamma transitions were assumed to be (50%M1 + 50%E2). Theoretical internal conversion coefficients were adopted from the derivations and interpolations of Kibedi et al (2005). Population/depopulation considerations of the various nuclear levels also resulted in minor adjustments to the weighted mean values of the relative emission probabilities of the 420.30-, 518.61-, 890.66- and 2747.88-keV gamma rays and the introduction of calculated relative emission probabilities for the 425.6- and 2186.27-keV gamma rays that are also part of the Zr-90m decay scheme (see separate decay data file). The 1760.71-keV E0 gamma transition has a small overall transition probability of approximately 0.0005%, and therefore was not included in the energy balance calculations. EC decay to the 4541.37-, 3448.23-, 3076.93-, 2747.88-, 2739.30-, 2319.00- (Zr-90m), 2186.27- and 1760.71-keV nuclear levels and the ground state of Zr-90 were assumed to be zero on the basis of spin and parity considerations. Thus, a normalization factor of 0.947(7) was calculated for the gamma-ray emission probabilities based on all of the above data and the derived decay scheme. Total EC transition probabilities were determined from consideration of the gamma-ray population/depopulation of each nuclear level of Zr-90, and positron components were estimated from the tabulations of Gove and Martin (1971).

There are a number of uncertainties within the detail of the proposed decay scheme (particularly with respect to the population/depopulation of the 3589.42-, 3448.23- and 3076.93-keV nuclear levels by the gamma transitions), and specific adjustments have been made to derive a complete and reasonably consistent data set. Further gamma-ray measurements are required to confirm, clarify and resolve various aspects of the decay scheme associated with the population/depopulation balances of the nuclear levels.

41-Nb- 90m

The half-life of 18.81(9) secs is the weighted mean of the measurements of Geiger et al (1969), Smend et al (1971), and Courtney et al (1974). A measurement by Meykens et al (1978) of 18.87(2) secs included an estimate of only the statistical uncertainty, and was therefore set aside.

A simple two-gamma cascade has been derived for the IT decay from the studies of Geiger et al (1969), Smend et al (1971) and Meykens et al (1978). Absolute emission probabilities of the resulting 2.33- and 122.37-keV gamma rays were derived from their 100% transition probabilities and the theoretical conversion coefficients of Kibedi et al (2005).

41-Nb- 90n

The half-life of 6.22(8) msecs is the weighted mean value of the measurements of Ivanov (1967), Courtney et al (1974), Hashizume et al (1974), and Delaune (1977).

A very simple IT decay scheme was derived from the equivalent EC-decay studies of Mo-90 by Pettersson et al (1966) and Cooper et al (1967), in which the 257.3-keV isomeric transition was characterised. The absolute emission probability of the 257.3-keV gamma ray was derived from the 100% transition probability and the theoretical conversion coefficients of Kibedi et al (2005), assuming (99%E3 + 1%M4) transition type.

48-Cd-113

The half-life of 7.8(3)E+15 years is the weighted mean value of the measurements of Gerth et al (1970), Alessandrello et al (1994) and Danevich et al (1996). Further measurements are merited to fortify the existing data set.

A very simple decay scheme has been derived that consists of a single beta transition directly to the ground state of In-113 (fourth forbidden non-unique). There is no evidence of any gamma-ray emissions.

48-Cd-113m

The half-life of 14.6(1) years is the weighted mean value of the two measurements of Flynn et al (1965) and five measurements of Wahl (1972). Further measurements are merited to fortify the existing data set.

A very simple decay scheme has been derived that consists of a single beta emission directly to the ground state of In-113, and one 263.54-keV E5 gamma-ray transition that constitutes the IT decay mode. The beta and IT branching fractions were calculated from the relative intensities of the gamma and beta radiation determined by der Mateosian and Goldhaber (1969):

$$P_\gamma(263.54\ \text{keV})/P_\beta = 0.00023(1).$$

Combining with $TP_\gamma(263.54\ \text{keV}) + P_\beta = 1.000$

gives $P_\beta = 0.9988(1)$ and $TP_\gamma = 0.0012(1)$.

Further studies are merited to clarify and support the proposed decay scheme.

50-Sn-121

The half-life of 26.99(0.10) hours is the weighted mean of the measurements of Nelson et al (1950), Majumdar and Chatterjee (1963), Lawrence et al (1966), and Erdal and Wahl (1968). A somewhat lower measurement of 25.5(1) hours by Snyder and Beard (1968) was set aside from this analysis. Further measurements are required to gain greater confidence in the recommended value.

A very simple decay scheme is proposed that consists of a single allowed beta transition directly to the ground state of Sb-121 (Snyder and Beard (1968)). There is no evidence for the existence of any gamma-ray emissions.

50-Sn-121m

The half-life of 43.9(5) years is based entirely on the measurement of Rech et al (2002). Further measurements are required to gain greater confidence in the recommended value.

A simple decay scheme has been derived from the studies of Snyder and Beard (1968), Hutchinson et al (1978) and Hansen et al (1982). Hutchinson et al determined an IT branching fraction of 0.776(20) from the 6.30-keV metastable level to the ground state of Sn-121. The remaining beta branching fraction of 0.224(20) populates the 37.133-keV nuclear level of Sb-121 prior to gamma decay to the ground state. Absolute emission probabilities for the 6.30- and 37.133-keV gamma rays were calculated from these branching fractions and the theoretical conversion coefficients derived from Kibedi et al. Measurements of the absolute gamma-ray and conversion-electron emission probabilities are required to define the proposed decay scheme with greater confidence.

66-Dy-166

The half-life of 81.6(2) hours is the weighted mean of the measurements of Gunnink and Stoner (1962) and Hoffman (1963). Further measurements are required to gain greater confidence in the recommended value.

Detailed features within the proposed decay scheme have been derived from the measurements of Brabec et al (1964), Badica et al (1979), and Sekine and Baba (1981). The gamma-ray studies of Brabec et al and Badica et al were made relative to the emission probability of the 82.472-keV gamma transition (100%). Brabec et al quantified the gamma rays with energies greater than 80 keV, while Badica et al focused on the gamma rays with energies less than 85 keV. Sekine and Baba determined the absolute emission probability of the 82.472-keV gamma ray to be 13.8(7)%. All (M1 + E2) gamma transitions were assumed to be 100%M1 (28.23-, 82.472- and 290.62-keV gamma rays). These various data were pieced together to derive an initial decay scheme. The beta transition probabilities were calculated from the relative gamma-ray emission probabilities, a normalisation factor of 0.138(7) and the theoretical conversion coefficients derived from Kibedi et al. Beta decay from the 0+ ground state of Dy-166 to the 2– excited state of Ho-166 was assumed to be zero (first forbidden unique), and resulted in a calculated beta-particle emission probability of 6.8(7)% directly to the 0– ground state of Ho-166. However, this combination of disparate data did not produce a consistent data set with respect to the relative emission probabilities of the 28.232- and 54.240-keV gamma-ray transitions as measured by Badica et al.

The resulting data are built up from three completely separate measurements – there are no gamma-ray studies that cover the full range of proposed gamma rays (i.e., from 28 to 430 keV). This form of assembly introduces a number of uncertainties into the proposed decay scheme, with specific assumptions having to be made concerning the relative merits of the gamma-ray data. Geiger et al (1960b) have determined the beta transition probability to the 82.472-keV nuclear level of Ho-166 to be 0.92(7) which has been subsequently adopted in this evaluation, resulting in significant adjustments to the relative emission probabilities of the 28.232- and 54.240-keV gamma rays (modified from 8.2(6)% and 5.9(9)% to 6.2(6)% and 3.6(4)%, respectively). This approach is highly questionable, and comprehensive measurements of the absolute and relative gamma-ray emission probabilities are required to define the proposed decay scheme with greater confidence.

69-Tm-170

The half-life of 128.6(3) days is the weighted mean value of the measurements of Kerrigan (1967) and Reynolds et al (1968). A half-life value of 127.1(9) days as determined by Lagoutine et al (1969) has been set aside. Further measurements are required to gain greater confidence in the recommended value.

The extremely accurate gamma-ray energy of 84.25474(8) keV was adopted from the proposed energy standards of Helmer and van der Leun (2000). A simple decay scheme has been derived from the various studies of Mohan et al (1970), Bulgakov et al (1979), Mehta et al (1985), Venkateswara Rao et al (1986), Geidelman et al (1987), Kuzmenko et al (1988), Kempisty et al (1990), and Egorov et al (1990). The relative emission probability of the 78.60-keV gamma ray was derived from the measurements of Mohan et al, Mehta et al, and Venkateswara Rao et al (relative to the 84.255-keV gamma ray (100%)), while the absolute emission probability of the 84.255-keV gamma ray (and normalisation factor) was determined from the measurements of Geidelman et al, Kuzmenko et al, and Kempisty et al. These data were used in conjunction with the theoretical conversion coefficients derived from Kibedi et al (2005) to quantify the gamma transition probabilities. An EC branching fraction of 0.00138(20) was calculated from the studies of Mohan et al, Venkateswara Rao et al, Kuzmenko et al, and Egorov et al. All of the resulting data were combined to produce a relatively simple and consistent decay scheme. Measurements of the absolute gamma-ray and conversion-electron emission probabilities are required to define the proposed decay scheme with greater confidence.

70-Yb-176m

The recommended half-life of 11.4(3) secs is the weighted mean of the measurements of Kantele (1962), Vergnes et al (1965), and Borggreen et al (1967).

A consistent decay scheme has been determined, assuming 100% IT decay in the form of a cascade of five gamma rays to the Yb-176 ground state (as observed by Borggreen et al (1967), Bocciolini et al (1967) and Tuurnala et al (1970)). The theoretical internal conversion coefficients derived from Kibedi et al have been used to calculate the absolute emission probabilities of all of the gamma-ray transitions (on the basis of an E1 96.0-keV gamma ray, and all other gamma rays defined as E2). Expressed as relative gamma-ray emission probabilities (relative to the 292.7-keV gamma ray (100%)), these data are in reasonable agreement with the equivalent measurements of Tuurnala et al. Measurements of the absolute emission probabilities of these gamma rays are merited to define the decay scheme with greater confidence.

75-Re-184

The half-life of 35.4(5) days is the weighted mean of the measurements of Johnson (33(3) days (1963)), Blichert-Toft (34(5) days (1965)) and Hayakawa et al (35.1(5), 36.0(9) and 35.6(5) days (2006, 2007 (same measurements reported twice))), with the uncertainty being the lowest measured by Hayakawa et al; measurements by Bodenstedt et al (38(1) days (1960)) and Dzhelepov et al (38.0(5) days (1963)) have been set aside. Nevertheless, the measurements used in the half-life evaluation are spread between 33 and 36 days, and further studies are merited to improve the quality of this adopted data set and confirm the recommended value.

A relatively complex decay scheme can be constructed from the conversion-electron and gamma-ray measurements of Ageev et al (1974) and McMillan et al (1974), supported by the additional multipolarity studies of Krane et al (1973), Canty et al (1973), Hübel et al (1973) and Klyuchnikov et al (1976). EC decay to the 748.3-keV nuclear level and ground state of W-184 were assumed to be zero on the basis of spin and parity considerations, while the EC decay to the 1130.03-keV nuclear level was found to be zero from gamma-ray population/depopulation calculations. Measured gamma-ray emission probabilities were obtained from Re-184m/Re-184 sources in secular equilibrium, and these data were decomposed when appropriate to obtain the metastable and ground state contributions. Theoretical internal conversion coefficients were adopted from the derivations and interpolations of Kibedi et al. A normalization factor of 0.430(11) was calculated for the gamma-ray emission probabilities from these data. EC transition probabilities were determined from consideration of the gamma-ray population/depopulation of each nuclear level of W-184, and EC and positron components for the 1116- and 1368-keV transitions were estimated from the tabulations of Gove and Martin.

There are a number of uncertainties within the detail of the proposed decay scheme, and specific adjustments have been made to derive a complete and reasonably consistent data set. Further gamma-ray measurements are required to confirm, clarify and resolve various aspects of the decay scheme associated with population/depopulation balances of the nuclear levels.

76-Os-189m

The half-life of 5.81(10) hours is the weighted mean value of the measurements of Scharff-Goldhaber et al (1958), Prospero (1963), and Ahmad et al (2000), with the uncertainty increased to the minimum measured value. Since no uncertainty was quoted in the half-life measurement of Otozai et al, this value was discarded.

A very simple IT decay scheme has been derived from the studies of Newton (1960), Prospero

(1963), and Malmskog et al (1970). An absolute emission probability of 0.000321(10)% for the 30.81-keV gamma ray was calculated from the 100% transition probability and the theoretical conversion coefficients of Kibedi et al (2005). Although in some doubt, the gamma transition type was assumed to be 99.84%M3 + 0.16%E4, based primarily on the conversion-electron studies of Malmskog et al (L-II/L-III ratio).

78-Pt-190

Pt-190 undergoes alpha decay directly to the ground state of Os-186 only, without emitting any gamma rays. The half-life of 6.5(3)E11 years is the weighted mean of the measurements of MacFarlane and Kohman (1961), Petrzhak and Yakunin (1962), Graeffe (1963), and Al-Bataina and Jänecke (1987), with the uncertainty adjusted upwards to conform with the lowest measured value.

The energy of the single alpha-particle emission has been calculated from the recommended Q(α) value. Fremlin and Walters (1952) studied the possibility of double-beta decay ($\varepsilon\beta^+$), and derived a lower limit to the half-life for this decay mode of 3.1E11 years which is significant (Tretyak and Zdesenko (2002)); this $\varepsilon\beta^+$ decay mode needs to be assessed further in order to determine the possible impact on the proposed decay scheme.

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