CEA-R-5990

ISSN 0429 - 3460

COMMISSARIAT À L'ÉNERGIE ATOMIQUE

REPORT ON THE ACTIVITIES OF THE (COMPTE-RENDU D'ACTIVITÉ DU GROUPE) «DECAY DATA EVALUATION PROJECT»

par

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DÉPARTEMENT D'INSTRUMENTATION ET DE MÉTROLOGIE DES RAYONNEMENTS IONISANTS

DIRECTION DE LA RECHERCHE TECHNOLOGIQUE

RAPPORT R

DIRECTION DES TECHNOLOGIES DE L'INFORMATION

CEA / SACLAY 91191 GIF-SUR-YVETTE CEDEX FRANCE

2001

RAPPORT CEA-R-5990

Report CEA-R-5990(E)

Report on the Activities of the Decay Data Evaluation Project (DDEP) October 2001

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I. Summary

This report summarizes the work of the DDEP collaboration since its establishment in 1994. It also presents a projected schedule of nuclear data evaluations for 2002 – 2003, and the minutes of the DDEP Meeting held at Braunschweig, Germany, May 15, 2001. The objective of this meeting was to:

- Review progress in the production of nuclear data evaluations.
- Assess its current work force.
- Plan the next publication of the Table of Radionuclides.
- Coordinate evaluation activities with the International Atomic Energy Agency (IAEA) Coordinated Research Programme (CRP).
- Integrate DDEP evaluation procedures with those used in the production of the Evaluated Nuclear Structure Data File (ENSDF), maintained by the Brookhaven National Laboratory, USA.

A sample of a DDEP evaluation is presented in this report.

Résumé

Ce document résume les travaux effectués dans le cadre de la collaboration « Decay Data Evaluation Project » depuis sa création en 1994. Il inclut, également, un exemple de publication déjà effectuée par le DDEP ainsi que le compte-rendu de la réunion qui s'est tenue à Braunschweig (Allemagne) le 15 mai 2001 et un agenda des travaux futurs. Les objectifs de cette réunion étaient :

- La revue des évaluations en cours ;
- L'évaluation de la force de travail présente et à venir ;
- Les prévisions pour la publication d'un nouveau volume de la Table des Radionucléides ;
- La coordination des activités d'évaluations en relation avec le groupe de travail de l'AIEA ;
- L'intégration des procédures d'évaluations du groupe DDEP avec celles utilisées par ENSDF (maintenue par Brookhaven National Laboratory, USA).

II. Preface

High-quality evaluated nuclear and atomic data are needed in applied research and for detector calibrations. Using inaccurate gamma-ray emission probabilities may result in serious miscalculations, which, in the power reactor industry could involve large amounts of radioactive material. Similarly, for radionuclides used in nuclear medicine a wrong radiation dose could have detrimental consequences on the patient's health. For detector calibrations, the effect of inaccurate standards may be propagated to actual measurements, thus producing incorrect results that are often difficult to identify.

During the last four decades several research groups have undertaken the compilation and evaluation of nuclear decay data to provide the best values needed in these fields. By 1991 it was clear that coordinating the efforts of these groups would help resolve the following two problems: First, the reduction in the funding of data evaluation efforts, which obviously dictated a more efficient use of human resources. Second, several published evaluations presented different recommended values, which was disconcerting. The same year Richard G. Helmer initiated a discussion with members of the radiation standards laboratories in Germany and France (i.e., Physikalisch-Technische Bundesanstalt, in Braunschweig, and what has become Laboratoire National Henri Becquerel, in Saclay) concerning the feasibility of a cooperative program for the evaluation of nuclear decay data that would coordinate the national efforts. Within a couple of years, France and Germany had reached an agreement. In 1994 the evaluators from the United States of America received approval to participate in this effort, and soon evaluators from Russia and the United Kingdom joined them.

The first meeting of the new Decay Data Evaluation Project (DDEP) was held in Paris, in 1995. The organization of the DDEP has been informal since its genesis. Its members have participated on the basis of their personal interest (with approval from their respective management). In its initial meetings, this collaboration addressed the questions of objectives, working procedures, and goals. That is, selecting which radionuclides should be evaluated, establishing evaluation methods, and deciding upon the various procedures for disseminating and publishing the evaluations. It has been agreed that the goal would be to evaluate nuclear decay data for about 250 radionuclides of interest in applied research. The list includes those that are important in the nuclear power industry, nuclear medicine, remediation of nuclear waste, and radionuclides commonly used for the calibration of gamma-ray detectors. The collaboration has adopted uniform and well-defined procedures for analyzing data, and has agreed that the evaluations would be published in laboratory reports. In addition, it has been decided that the evaluated data will be stored in the French NUCLEIDE database, and will be made available to the National Nuclear Data Center, Brookhaven National Laboratory (USA) for inclusion in their database.

III. Membership

The following research centers are members of the DDEP collaboration as of October 2001:

- Commissariat à l'Énergie Atomique/ Laboratoire National Henri Becquerel, Saclay, France
- Lawrence Berkeley National Laboratory, Berkeley, California, USA
- Physikalisch-Technische Bundesanstalt, Braunschweig, Germany
- Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho, USA
- V.G. Khlopin Radium Institute, St. Petersburg, Russia
- Centro de Investigaciones Energéticas, Medioambientales, y Tecnológicas, Madrid, Spain
- Universidad Nacional de Educación a Distancia, Madrid, Spain
- HMS Sultan, Gosport, Hampshire, UK
- AEA Technology, Harwell, Oxon, UK
- National Physical Laboratory, Teddington, Middlesex, UK

IV. Minutes of the DDEP Meeting held in Braunschweig, Germany, May 15, 2001

1. List of participants

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2. Coordination of the DDEP collaboration

As R. G. Helmer had retired from full-time employment two years ago, he wished to pass on the DDEP coordinating role to E. Browne, Lawrence Berkeley National Laboratory. The meeting approved this change.

3. Status of evaluations

E. Browne reported that 29 DDEP evaluations had been published in the *Table of Radionucléides* (ISBN 2 7272 0200 8), 31 in preliminary PTB reports (PTB-6.11-97-1 and PTB-6.11-00-1), an additional 18 had been completed (12 new and 6 updated evaluations), and 14 evaluations are currently in progress (See section V, Table 1).

4. Future participation of PTB in the DDEP collaboration

H. Janβen, head of the PTB data evaluation group, reported on the following recent staff changes that may affect the laboratory's participation in the DDEP collaboration:

- E. Schönfeld retired at the end of February 2001;
- H. Schrader will continue to do some evaluation and will be joined by R. Dersch, a young scientist who was introduced to the collaboration at this Meeting.

H. Janβen emphasised the importance to PTB of internationally collaborating with the DDEP, and he expressed his support for continuing their contribution to this effort. Although R. Dersch will assume E. Schönfeld's evaluation responsibilities, H. Janβen noted that PTB staff has been decreasing by 1.5% per annum, making more difficult such a commitment as time goes by E. Browne expressed appreciation for the invaluable contribution from PTB, and optimism for the work that remains to be done.

5. Next publication of DDEP evaluations

Evaluators will send 18 *new* and *updated* evaluations to M.M. Bé (Saclay) before the end of 2001. In addition, it was expected that at least 6 evaluations (out of 14) in progress could be completed by the same time (see Table 1). These evaluations will be part of a new report, with the same layout as was used in the previous one, to be published in 2002.
A. Nichols passed his evaluations of ^{56}Mn and ^{203}Hg to E. Browne for review.

6. Work force and projected evaluations for 2002-2003

The current number of members in the DDEP collaboration is 12, although not all of them have started their evaluation activities yet. Table 2 shows the DDEP projected production schedule for 2002 – 2003 based on the available human resources.

7. Revision of the review process

E. Browne discussed various ways in which the review process could be speeded up and made more effective. His suggestions were sent out in a proposal dated February 2001, which is attached as Appendix 1 to this report. Evaluations would be electronically transmitted for review as Microsoft Word (or WordPerfect) documents. The possibility of sending output files produced by M.M. Be's computer program from the NUCLEIDE database was considered. However, these are Portable Document Format (PDF) files, so the reviewer would need the full Adobe Acrobat software to modify them. Another possibility is to indicate the corrections on paper and fax them, or to send long comments by E-mail. The main idea was to use electronic transmission rather than traditional (and slower) airmail.
The meeting approved the use of the new procedures given in Appendix 1.

8. Evaluation needs of the IAEA Coordinated Research Programme (CRP)

A. Nichols reported that this CRP was dealing with a smaller set of nuclides than was DDEP. Furthermore, for each nuclide, a smaller set of nuclear data is being considered. The IAEA is aiming for another report similar to TECDOC-619. A. Nichols referred to the ^{125}Sb evaluation from the 1st CRP as an example of the format being followed by the 2nd CRP.
It was pointed out that the CRP and DDEP have independently evaluated half-lives with slightly different approaches to dealing with discrepant data. There is a possibility of different values, or values with different uncertainties, being recommended by the two groups. Such a situation should be avoided, if at all possible. It was suggested that, where possible, CRP data could be extracted from DDEP evaluations, either by DDEP evaluators or by Mike Herman at IAEA.

E. Browne and R. Helmer undertook to send to A. Nichols the gamma-ray and half-life data for two nuclides using a format similar to that of the IAEA TECDOC-619 report.

E. Schönfeld reported that he had calculated X-ray data for the 60 nuclides in the CRP. He undertook to forward these data to E. Browne and R. Helmer.

9. LNHB software for displaying tables and text

M.M. Bé informed the meeting that a complete software package on Access 2000 was available with the following improvements:

- Automatic input, from tables, of constant data like fluorescence yields and Q-values;
- Automatic derivation of absolute γ-ray intensities (including uncertainties) from relative γ-ray intensities;
- Direct link with the external software tools: LWEIGHT (calculation of averages), EC-capture (calculation of fractional electron capture probabilities), ICC v3.99 (calculation of internal conversion coefficients);
- Calculation of γ-ray transition intensities, and conversion electron energies and intensities (including uncertainties);
- Production of input files for the EMISSION program (for calculating X-rays and Auger electrons intensities) and the transfer of results to the NUCLÉIDE database;
- Addition of a conversion module to produce ENSDF data sets.

10. Integrating DDEP evaluations with the *Evaluated Nuclear Structure Data File* (ENSDF)

A. Software

The DDEP collaboration and the International Network of Nuclear Structure and Decay Data (NSDD) Evaluators produce data evaluations for use in nuclear spectroscopy and its applications. However, the objective of the DDEP collaboration is exclusively to evaluate data of interest in applied research and for detector calibration. These data represent a subset of ENSDF. Obviously, it would be highly desirable to use the same procedures for calculating quantities, both in our DDEP evaluations and in ENSDF. Usual quantities calculated in DDEP evaluations are alpha-hindrance factors, log ft values, and average radiation energies. The NSDD developed for this purpose the following PC programs:

- LOGFT, to calculated log ft's in β^-, and EC + β^+ decays.
- ALPHAD, to calculate hindrance factors in alpha decay.
- RADLST, to calculate X rays, atomic electrons, and average radiation energies.

These programs can be downloaded from the National Nuclear Data Center, Brookhaven National Laboratory home page (www.nndc.bnl.gov), more specifically, from www.nndc.bnl.gov/nndc/ensdfpgm). They require input data in the ENSDF format, which can be produced by the French software NUCLEIDE. Instruction Manuals describing formats and types of data in ENSDF may be downloaded from www.nndc.bnl.gov/nndc/nndcnsdd.html#manuals. E. Browne urged members of the DDEP collaboration to use these programs. Also, log ft values and interpolated conversion coefficients (Hager and Seltzer, Band) may be interactively calculated using the "Nuclear Structure Calculational Tools" (www.nndc.bnl.gov/nndc/physco).

B. Rounding numbers

It would be useful to adopt a uniform policy for rounding numbers in DDEP evaluations. In ENSDF the policy for rounding numbers is as follows:

Uncertainties should have no more than two digits

Uncertainties >25 should be rounded to 3 in the least significant digit.

Examples:	318.20 ±0.15	318.20 (15)
	318.20±0.32	318.2 (3)
	318.20±0.38	318.2 (4)

C. γ-ray Mixing Ratios

E. Browne suggested using in DDEP evaluations the mixing ratios given in ENSDF, unless significantly more precise values had become available after the ENSDF evaluation. Also, it would be helpful to consult the tables of "E2, M1 Multipole Mixing Ratios in Nuclei," by K.S. Krane [1]

D. Theoretical Conversion Coefficients

Values in ENSDF are from calculations of Hager & Seltzer [2] or Band, whereas those in DDEP evaluations are from Rösel [3]. In general, these theoretical conversion coefficients

have shown agreement with experiment to within 3%. New calculated conversion coefficients (by Band [4]) will be published soon. The results of these calculations apparently agree extremely well with experiment. Since these new values are not available yet, E. Browne suggested continuing to use values from Rösel in DDEP evaluations.

11. Discrepant data

The possible benefits of using the median of a set of discrepant data were discussed. The median is not very sensitive to outliers.

An uncertainty can be assigned to the median using the following formula:

$S(m) = MAD \times 1.9/\sqrt{(n-1)}$

Where MAD is the 'median of the absolute deviations'

J.M. Los Arcos reported that he is developing a new technique for evaluating discrepant data and was requested to circulate details of his method when it is ready for publication.

DDEP will consider further the question of discrepant data following publication of the above paper.

To assist in the evaluation of data sets, T.D. MacMahon was asked to provide a table showing the value of reduced χ^2 (chi-squared) at a 95% (2 standard deviation) confidence level for varying number of data values. Such a table is attached as Appendix 2.

12. A World Wide Web (WWW) home page for the DDEP collaboration

It was agreed that it would be valuable for DDEP to have its own pages on the World Wide Web (WWW). The pages would contain information on the structure of DDEP and lists of evaluations completed and in progress. Evaluated data would be available as read-only pdf files.
J.M. Los Arcos made a provisional offer to set up set Web pages at CIEMAT, this offer being subject to confirmation.

V. Status of evaluations as of September 2001

1. Evaluations in progress, completed, and published.

The status of evaluations as of September 2001 is as follows: 29 DDEP evaluations have been published in the *Table of Radionuclides*, 31 in preliminary PTB reports (PTB-6.11-97-1 and PTB-6.11-00-1), an additional 18 have been completed (12 new and 6 updated evaluations), and 14 evaluations are currently in progress (of these, ^{57}Co, ^{125}Sb, ^{125}Te^{m}, ^{129}I, ^{154}Eu, and ^{155}Eu may be completed in 2001.) Table 1 below presents the status of each evaluation.

Table 1. DDEP evaluations.

Radionuclide	Eval. Center[&]	Status[†]		
		Preliminary Publication	Current[*]	Publication
^{3}H (12.33 y)	KRI			Table of Radionuclides[#]
^{7}Be (53 d)	INEEL, PTB	Rept. PTB-6.11-97-1	Updated (2001)	
^{14}C (5730 y)	KRI			Table of Radionuclides[#]
^{22}Na (2.6 y)	INEEL, PTB	Rept. PTB-6.11-97-1		Table of Radionuclides[#]
^{24}Na (14 h)	INEEL, PTB	Rept. PTB-6.11-97-1	Updated (2001)	
^{26}Al (720 Ky)	LBNL	Rept. PTB-6.11-97-1		Table of Radionuclides[#]
^{35}S (87.5 d)	KRI			Table of Radionuclides[#]
^{36}Cl (300 Ky)	KRI			Table of Radionuclides[#]
^{41}Ar (109 min)	INEEL	Rept. PTB-6.11-00-1		
^{40}K (1.2 Gy)	INEEL			Table of Radionuclides[#]
^{44}Sc (3.9 h)	LBNL		Completed (1999)	
^{46}Sc (83 d)	INEEL		Completed (2001)	
^{44}Ti (60 y)	LBNL		Completed (1999)	
^{51}Cr (27 d)	INEEL, PTB	Rept. PTB-6.11-97-1	Updated (2001)	
^{54}Mn (312 d)	PTB, INEEL	Rept. PTB-6.11-97-1	Updated (2001)	
^{56}Mn (2.58 h)	AEA[£]		Work in progress (1999)	
^{55}Fe (2.7 y)	LNHB			Table of Radionuclides[#]
^{59}Fe (44.5 d)	LNHB		Work in progress (2001)	
^{60}Fe (1.5 My)	LBNL		Completed (1999)	
^{57}Co (271 d)	KRI		Work in progress (1999)	
^{56}Co(77.2 d)	NPL		Work in progress (2001)	
^{58}Co (70 d)	LNHB			Table of Radionuclides[#]
^{60}Co (5.2 y)	INEEL	Rept. PTB-6.11-97-1		Table of Radionuclides[#]
^{57}Ni (35.6 h)	LBNL		Completed (1999)	
^{65}Zn (244 d)	INEEL	Rept. PTB-6.11-97-1		Table of Radionuclides[#]
^{67}Ga (3.26 d)	KRI		Completed (2001)	

Table 1. (cont.)

Radionuclide	Eval. Center[&]	Status[†]		
		Preliminary Publication	**Current[*]**	**Publication**
^{68}Ga(67.6 min)	PTB	Rept. PTB-6.11-97-1		Table of Radionuclides[#]
^{68}Ge (270.8 d)	PTB	Rept. PTB-6.11-97-1		Table of Radionuclides[#]
^{75}Se (119 d)	LBNL, PTB	Rept. PTB-6.11-97-1		Table of Radionuclides[#]
^{85}Sr (64.8 d)	PTB	Rept. PTB-6.11-00-1		
^{89}Sr (50.5 d)	PTB	Rept. PTB-6.11-00-1		
^{95}Zr (64 d)	INEEL			Table of Radionuclides[#]
^{88}Y (106.6 d)	PTB	Rept. PTB-6.11-00-1		
^{93}Nb^{m} (16 y)	KRI		Completed (2001)	
^{95}Nb^{m} (3.6 d)	INEEL			Table of Radionuclides[#]
^{95}Nb (34 d)	INEEL			Table of Radionuclides[#]
^{99}Mo (2.7 d)	LNHB, KRI		Updated (2001)	
^{99}Tc (211 Ky)	LNHB		Work in progress (1999)	
^{99}Tc^{m} (6.0 h)	LNHB, KRI		Updated (2001)	
^{109}Cd (1.2 y)	PTB	Rept. PTB-6.11-97-1		
^{111}In (2.8 d)	KRI			Table of Radionuclides[#]
^{111}In^{m} (1.6 h)	INEEL, LNHB			Table of Radionuclides[#]
^{113}Sn (115 d)	INEEL			Table of Radionuclides[#]
^{125}Sb (2.76 y)	CIEMAT,UNED		Work in progress (1999)	
^{123}Te^{m} (119 d)	LNHB, PTB	Rept. PTB-6.11-97-1		Table of Radionuclides[#]
^{125}Te^{m} (58 d)	CIEMAT,UNED		Work in progress (1999)	
^{123}I (13 h)	LNHB		Work in progress (2001)	
^{125}I (60 d)	PTB	Rept. PTB-6.11-97-1		Table of Radionuclides[#]
^{129}I(1.6×10^{7} y)	KRI		Work in progress (1999)	
^{131}I (8 d)	LNHB		Work in progress (2001)	
^{137}Cs (30 y)	INEEL, PTB	Rept. PTB-6.11-97-1		Table of Radionuclides[#]
^{133}Ba (10 y)	KRI		Completed (2000)	
^{140}Ba (12 d)	INEEL	Rept. PTB-6.11-00-1		
^{140}La (1.6 d)	INEEL	Rept. PTB-6.11-00-1		
^{139}Ce (137 d)	PTB, INEEL	Rept. PTB-6.11-97-1		Table of Radionuclides[#]
^{141}Ce (32 d)	PTB	Rept. PTB-6.11-97-1		Table of Radionuclides[#]
^{143}Pr (13.57 d)	BNL		Completed (1999)	
^{152}Eu (13.51 y)	USP, LBNL		Completed (2001)	
^{153}Sm (1.9 d)	INEEL	Rept. PTB-6.11-97-1	Updated (2001)	
^{154}Eu(8.59 y)	KRI		Work in progress (1999)	
^{155}Eu(4.76 y)	KRI		Work in progress (1999)	
^{153}Gd (241 d)	INEEL	Rept. PTB-6.11-97-1	Updated (2001)	

Table 1. (cont.)

Radionuclide	Eval. Center[&]	Status[†]		
		Preliminary Publication	**Current[*]**	**Publication**
^{166}Ho (26.8 h)	PTB	Rept. PTB-6.11-00-1		
^{166}Ho^{m} (1.2 Ky)	PTB	Rept. PTB-6.11-00-1		
^{169}Yb (32 d)	LNHB, PTB	Rept. PTB-6.11-00-1		
^{170}Tm (128 d)	KRI		Completed (2000)	
^{186}Re (90.6 h)	PTB	Rept. PTB-6.11-00-1		
^{188}Re (16 h)	LBNL			Table of Radionuclides[#]
^{192}Ir (73 d)	LBNL	Rept. PTB-6.11-97-1		Table of Radionuclides[#]
^{194}Ir (19 h)	LBNL			Table of Radionuclides[#]
^{198}Au (2.6 d)	PTB	Rept. PTB-6.11-00-1		
^{203}Hg (46.6 d)	AEA		Work in progress (1999)	
^{201}Tl (72.9 h)	PTB	Rept. PTB-6.11-97-1		
^{207}Bi (32.2 y)	LNHB			Table of Radionuclides[#]
^{241}Am (432y)	KRI		Completed (2000)	
^{252}Cf (2.645 y)	LNHB		Work in progress (1999)	

[†] Evaluations are produced in two formats: LNHB, as presented in the *Table of Radionuclides*, and ENSDF, for generating reports with a style similar to that of the *Nuclear Data Sheets*.
[£] Evaluations produced for the IAEA Coordinated Research Programme (CRP).
[#] Table of Radionuclides, Laboratoire Primaire des Rayonnements Ionisants, ISBN 2 7272 0200 8, Saclay, Février 1999.
[*] Evaluations that have not been published yet.

[&]KRI - Khlopin Radium Institute, St. Petersburg, Russia
INEEL - Idaho National Engineering and Environmental Laboratory, Idaho Falls, ID, USA
PTB - Physikalisch-Technische Bundesanstalt, Braunschweig, Germany
LNHB - Laboratoire National Henri Becquerel, Saclay, France
BNL - Brookhaven National Laboratory, Upton, NY, USA
AEA - AEA Technology, Harwell, UK.
CIEMAT - Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, Madrid, Spain
UNED - Universidad Nacional a Distancia, Madrid, Spain.
LBNL - Lawrence Berkeley National Laboratory, Berkeley, CA, USA
USP - Universidade de São Paulo, Brazil.
NPL - National Physical Laboratory, Teddington, UK.

2. Projected evaluations for 2002 – 2003

At the meeting in Braunschweig, the DDEP collaboration anticipated the completion of data evaluations for over 30 radionuclides, as listed below in Table 2. This projection might seem somewhat optimistic. However, the current evaluators' experience, the well-established methodology that the DDEP applies to their evaluations, and especially, the development of new computer programs, have all significantly contributed to improve efficiency, and to make this goal more realistic.

Table 2. Projected evaluations for 2002 - 2003

Evaluation Center	Radionuclides
LNHB	^{11}C, ^{15}O, ^{103}Pd, ^{108}Ag^{m}, ^{213}Bi
INEEL	^{64}Cu, ^{110}Ag^{m}, ^{226}Ra decay chain
LBNL	^{56}Co*(with NPL), ^{227}Ac, ^{227}Th, ^{223}Ra, ^{134}Cs*(with USP)
KRI	Transuranium radionuclides
CIEMAT	^{131}Cs, ^{59}Ni, ^{66}Ga*, ^{243}Am*
AEA	^{228}Th decay chain*, ^{234}Pa^{m}*
NPL	^{144}Pr, ^{144}Ce
HMS	^{233}Th, ^{233}Pa

* IAEA Coordinated Research Programme (CRP)

VI. Other publications on nuclear data evaluation by members of the DDEP collaboration.

M.M. Bé, J. Lamé, F. Piton, F. Lagoutine, N. Coursol, J. Legrand, B. Duchemin, C. Morillon, E. Browne, V. Chechev, R. Helmer, E. Schönfeld, " NUCLÉIDE, Table of Radionuclides on CD-Rom", Version 1-98, CEA/DIMRI, 91191 Gif-sur-Yvette, France, (1999).

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VII. Appendix 1

A Plan for Processing Nuclear Data Evaluations

E. Browne

February 2001

The procedure outlined below presents a uniform and effective mechanism for reviewing data evaluations. It makes use of electronic editing and file transfer to significantly reduce the processing time and thus increase their availability.

I. Submitting Data Evaluations

Data evaluations prepared with WORD (or WORD PERFECT) text processors should be sent by e-mail (as attached files) to:

E. Browne
ebrowne@lbl.gov

Evaluators should send me two files, one containing numerical tables, the other describing the evaluation procedure that was followed for each specific radionuclide. I will acknowledge receipt of these files.

II. Sending Evaluations to Review (*One week*)

Upon receiving the evaluation I would normally send it by e-mail (as an attached file) to a reviewer within about a week. All of the reviewer's suggested modifications should be indicated in the original text by using the "Track Changes - Highlight Changes" options in WORD (or the equivalent options in WORD PERFECT).

III. Returning Reviewed Evaluations to LBNL. (Four weeks)

I expect reviewers to spend no more than about four weeks on each evaluation, and to return them to me by e-mail. I will spot check the reviewer's suggestions, and occasionally may include (in different color) my own suggestions before sending the material to the evaluator.

IV. Returning Revised Evaluations to LBNL. (*Three weeks*)

I expect the evaluator to consider the suggestions from the reviewer, and to return to me by e-mail his/her revised evaluation in about three weeks. The evaluator should send me the WORD (or WORD PERFECT) files, the MDB file for the NUCLEIDE database, and an ENSDF data set.

V. Sending the Revised Evaluation to LNHB. (*Two weeks*)

I will send by e-mail copies of all the files from the revised evaluation to LNHB within about two weeks. The MDB files will be included in the NUCLEIDE database. After writing specific comments for identification, I will send the ENSDF file to the Brookhaven National Laboratory for inclusion into the ENSDF database.

VI. Publication-Quality Copy of Evaluation

A publication-quality copy of the evaluation, which includes a decay scheme, will be produced at LNHB and sent to LBNL. Of course, the evaluator also could request a copy from LNHB.

VIII. Appendix 2

Values of reduced chi-squared (χ_v^2) at a 95% confidence level

Number of data points	Reduced chi-squared	Number of data points	Reduced chi-squared	Number of data points	Reduced chi-squared
1		21	1.571	41	1.394
2	3.841	22	1.556	42	1.389
3	2.996	23	1.542	43	1.384
4	2.605	24	1.529	44	1.379
5	2.372	25	1.517	45	1.375
6	2.214	26	1.506	46	1.370
7	2.099	27	1.496	47	1.366
8	2.010	28	1.486	48	1.362
9	1.938	29	1.476	49	1.358
10	1.880	30	1.468	50	1.354
11	1.831	31	1.459	55	1.336
12	1.789	32	1.451	60	1.321
13	1.752	33	1.444	65	1.307
14	1.720	34	1.436	70	1.296
15	1.692	35	1.430	75	1.285
16	1.666	36	1.423	80	1.275
17	1.644	37	1.417	85	1.267
18	1.623	38	1.411	90	1.259
19	1.604	39	1.405	95	1.251
20	1.587	40	1.399	100	1.245

Table extracted from The CRC Handbook of Tables for Probability and Statistics, 2nd edition, CRC Press Inc., 1968.

IX. Appendix 3: Software tools developed by members of the DDEP collaboration

The following computer codes have been developed for analyzing and processing nuclear data:

LWEIGHT : For calculating averages of consistent and discrepant data sets.
D. MacMahon (HMS Sultan) and E. Browne (LBNL), version 1.3, March 2000

EC-CAPTURE : For calculating electron capture probabilities to atomic sub shells of allowed and non-unique first forbidden transitions
E. Schönfeld (PTB), F. Chu and E. Browne (LBNL)

EMISSION : For calculating K- and L-x ray, as well as K- and L- electron Auger emission probabilities.
E. Schönfeld and H. Janßen (PTB)

ICC99 : For interpolating internal conversion coefficients from Hager and Seltzer [2]. , Rösel *et al.*[3], and from the new Band *et al.* tables [4].
V.M. Gorozhankin, N. Coursol, E.A. Yakushev (LNHB) [5,6,7]

SAISINUC : For entering (and checking) decay data into the NUCLéIDE database. This code is linked to those listed above.
From LNHB

NUCLÉIDE : A database for managing and displaying nuclear data, as well as for drawing decay schemes. Available on CD-Rom.
From LNHB

(These computer codes may be requested from the authors)

X. References

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XI. Appendix 4

An example of a published evaluation: ^{75}Se electron-capture decay.

$^{75}_{34}\mathrm{Se}_{41}$

1 Decay Scheme

Se-75 disintegrates 100% by electron capture to excited level and to the ground state of As-75. The 303 keV level of As-75 has a half-life of 16,8 ms.

Le Se-75 se désintègre à 100% par capture électronique vers des niveaux excités et le niveau fondamental de As-75. Le niveau de 303 keV a une période de 16,8 ms.

2 Nuclear Data

$T_{1/2}(^{75}\mathrm{Se}\ )$: 119,79 (4) d
$Q^{+}(^{75}\mathrm{Se}\ )$: 863,6 (8) keV

2.1 Electron Capture Transitions

	Energy keV	Probability × 100	Nature	lg ft	P_K	P_L	P_M
$\epsilon_{0,9}$	42,0 (8)	0,00040 (4)	1st Forbidden	9,2			
$\epsilon_{0,8}$	245,9 (8)	0,0162 (5)	1st Forbidden	9,3			
$\epsilon_{0,7}$	291,4 (8)	0,038 (5)	1st Forbidden	9,1			
$\epsilon_{0,6}$	395,0 (8)	0,00034 (8)	1st Forbidden	11,4			
$\epsilon_{0,5}$	462,9 (8)	95,9 (9)	Allowed	6,1	0,8770 (16)	0,1033 (15)	0,0179 (5)
$\epsilon_{0,3}$	584,1 (8)	≥2,2	1st Forbidden	≤7,9	0,8781 (16)	0,1025 (15)	0,0177 (5)
$\epsilon_{0,2}$	598,9 (8)	≤0,8	1st Forbidden	≥8,4	0,8782 (16)	0,1024 (25)	0,0177 (5)
$\epsilon_{0,0}$	863,6 (8)	1,1 (5)	1st Forbidden	8,6	0,8794 (15)	0,1014 (14)	0,0175 (5)

2.2 Gamma Transitions and Internal Conversion Coefficients

	Energy keV	$P_{\gamma+ce}$ × 100	Multipolarity	α_K	α_L	α_M	α_T
$\gamma_{3,2}$(As)	14,8847 (13)	0,0012 (6)	[M1+E2]				
$\gamma_{4,3}$(As)	24,3815 (14)	6,0 (4)	M2+0,26%E3	169 (4)	45 (4)	8,0 (7)	222 (9)

	Energy keV	$P_{\gamma+ce}$ × 100	Multipolarity	α_K	α_L	α_M	α_T
$\gamma_{2,1}$(As)	66,0518 (8)	1,54 (5)	M1+2,8%E2	0,34 (3)	0,042 (3)	0,0080 (6)	0,39 (4)
$\gamma_{3,1}$(As)	80,9365 (15)	0,021 (6)	E2	1,48 (4)	0,221 (7)	0,037 (1)	1,74 (5)
$\gamma_{5,4}$(As)	96,7340 (9)	6,5 (1)	E2	0,77 (2)	0,106 (3)	0,024 (1)	0,90 (3)
$\gamma_{5,3}$(As)	121,1155 (11)	17,9 (4)	E1	0,0375 (11)	0,00400 (12)	0,000700 (21)	0,0422 (13)
$\gamma_{5,2}$(As)	136,0001 (6)	60,0 (7)	E1	0,0265 (8)	0,00280 (8)	0,000478 (14)	0,0298 (9)
$\gamma_{1,0}$(As)	198,6060 (12)	1,51 (4)	M1+13%E2	0,0186 (12)	0,00205 (12)	0,00035 (2)	0,0210 (14)
$\gamma_{9,7}$(As)	249,3 (3)	0,000094 (24)	[M1+E2]				
$\gamma_{2,0}$(As)	264,6576 (9)	59,3 (3)	M1+1,2%E2	0,0065 (2)	0,00069 (2)	0,000110 (3)	0,0073 (2)
$\gamma_{3,0}$(As)	279,5422 (10)	25,21 (13)	M1+21%E2	0,0077 (6)	0,00083 (6)	0,000130 (9)	0,0087 (7)
$\gamma_{4,0}$(As)	303,9236 (10)	1,387 (8)	E3	0,0472 (14)	0,00602 (18)	0,00103 (3)	0,0542 (16)
$\gamma_{7,1}$(As)	373,61 (24)	0,00249 (24)	[E2]	0,0058 (2)	0,00064 (2)		0,0066 (2)
$\gamma_{5,0}$(As)	400,6572 (8)	11,49 (9)	E1	0,00122 (4)	0,000130 (4)		0,00137 (4)
$\gamma_{8,1}$(As)	419,1 (4)	0,0118 (5)	[M1+E2]				
$\gamma_{6,0}$(As)	468,6 (4)	0,00034 (8)	[M1+E2]				
$\gamma_{9,3}$(As)	542,02 (18)	0,000130 (24)	[M1+E2]				
$\gamma_{9,2}$(As)	556,90 (18)	0,000035 (12)	[E2]	0,00166 (6)	0,000176 (5)		0,00186 (6)
$\gamma_{7,0}$(As)	572,22 (24)	0,0357 (5)	M1+15,6%E2	0,0022 (6)	0,00023 (6)		0,0025 (7)
$\gamma_{8,0}$(As)	617,8 (4)	0,00444 (12)	[M1+E2]				
$\gamma_{9,0}$(As)	821,56 (18)	0,000137 (10)	[E2]				

3 Atomic Data

3.1 As

ω_K : 0,575 (4)
$\bar{\omega}_L$: 0,0155 (5)
n_{KL} : 1,232 (4)

3.1.1 X Radiations

		Energy keV		Relative probability
X_K				
	$K\alpha_2$	10,5080		52
	$K\alpha_1$	10,5437		100
	$K\beta_3$	11,720	}	
	$K\beta_1$	11,726	}	
	$K\beta_5''$	11,822	}	24
X_L				
	$L\ell$	1,11		
	$L\gamma$	– 1,38		

3.1.2 Auger Electrons

	Energy keV	Relative probability
Auger K		
KLL	8,75 – 9,10	100
KLX	10,12 – 10,54	31
KXY	11,44 – 11,80	2,4
Auger L	1,1 – 1,3	100

4 Photon Emissions

4.1 X-Ray Emissions

		Energy keV		Photons per 100 disint.	
XL	(As)	1,11 — 1,38		2,07 (7)	
XKα_2	(As)	10,5080		16,61 (21)	} Kα
XKα_1	(As)	10,5437		32,2 (4)	}
XKβ_3	(As)	11,720	}		
XKβ_1	(As)	11,726	}	0,077 (2)	K$'\beta_1$
XKβ_5''	(As)	11,822	}		

4.2 Gamma Emissions

	Energy keV	Photons per 100 disint.
$\gamma_{3,2}$(As)	14,8847 (13)	0,0012 (6)
$\gamma_{4,3}$(As)	24,3815 (14)	0,0270 (12)
$\gamma_{2,1}$(As)	66,0518 (8)	1,112 (12)
$\gamma_{3,1}$(As)	80,9365 (15)	0,0077 (24)
$\gamma_{5,4}$(As)	96,7340 (9)	3,42 (3)
$\gamma_{5,3}$(As)	121,1155 (11)	17,2 (3)
$\gamma_{5,2}$(As)	136,0001 (6)	58,2 (7)
$\gamma_{1,0}$(As)	198,6060 (12)	1,48 (4)
$\gamma_{9,7}$(As)	249,3 (3)	0,000094 (24)
$\gamma_{2,0}$(As)	264,6576 (9)	58,9 (3)

	Energy keV	Photons per 100 disint.
$\gamma_{3,0}$(As)	279,5422 (10)	24,99 (13)
$\gamma_{4,0}$(As)	303,9236 (10)	1,316 (8)
$\gamma_{7,1}$(As)	373,61 (24)	0,00247 (24)
$\gamma_{5,0}$(As)	400,6572 (8)	11,47 (9)
$\gamma_{8,1}$(As)	419,1 (4)	0,0118 (5)
$\gamma_{6,0}$(As)	468,6 (4)	0,00034 (8)
$\gamma_{9,3}$(As)	542,02 (18)	0,000130 (24)
$\gamma_{9,2}$(As)	556,90 (18)	0,000035 (12)
$\gamma_{7,0}$(As)	572,22 (24)	0,0356 (5)
$\gamma_{8,0}$(As)	617,8 (4)	0,00444 (12)
$\gamma_{9,0}$(As)	821,56 (18)	0,000137 (10)

5 Electron Emissions

		Energy keV	Electrons per 100 disint.
e_{AL}	(As)	1,1 - 1,3	1,31 (2)
e_{AK}	(As)		41,6 (5)
	KLL	8,75 - 9,10	}
	KLX	10,12 - 10,54	}
	KXY	11,44 - 11,80	}
$ec_{4,3\ K}$	(As)	12,5148 (16)	4,56 (3)
$ec_{4,3\ L}$	(As)	22,86 - 23,06	1,22 (13)
$ec_{4,3\ M}$	(As)	24,18 - 24,38	0,216 (22)
$ec_{2,1\ K}$	(As)	54,1851 (11)	0,38 (4)
$ec_{2,1\ L}$	(As)	64,53 - 64,73	0,047 (4)
$ec_{2,1\ M}$	(As)	65,84 - 66,05	0,0089 (7)
$ec_{3,1\ K}$	(As)	69,0698 (15)	0,011 (4)
$ec_{5,4\ K}$	(As)	84,8673 (13)	2,63 (9)
$ec_{5,4\ L}$	(As)	95,21 - 95,41	0,363 (12)
$ec_{5,4\ M}$	(As)	96,53 - 96,73	0,082 (3)
$ec_{5,3\ K}$	(As)	109,2488 (13)	0,643 (23)
$ec_{5,3\ L}$	(As)	119,59 - 119,79	0,0674 (24)
$ec_{5,3\ M}$	(As)	120,91 - 121,11	0,0115 (4)
$ec_{5,2\ K}$	(As)	124,1334 (10)	1,54 (5)
$ec_{5,2\ L}$	(As)	134,47 - 134,68	0,163 (6)
$ec_{5,2\ M}$	(As)	135,8 - 136,0	0,0278 (9)
$ec_{1,0\ K}$	(As)	186,7396 (12)	0,0275 (19)
$ec_{2,0\ K}$	(As)	252,7909 (12)	0,383 (17)
$ec_{2,0\ L}$	(As)	263,13 - 263,33	0,0406 (18)
$ec_{2,0\ M}$	(As)	264,45 - 264,66	0,0065 (3)

		Energy keV	Electrons per 100 disint.
$ec_{3,0\ K}$	(As)	267,6755 (13)	0,192 (17)
$ec_{3,0\ L}$	(As)	278,01 - 278,22	0,0207 (17)
$ec_{3,0\ M}$	(As)	279,34 - 279,54	0,0033 (2)
$ec_{4,0\ K}$	(As)	292,0569 (12)	0,0619 (19)
$ec_{4,0\ L}$	(As)	302,4 - 302,6	0,0079 (24)
$ec_{4,0\ M}$	(As)	303,72 - 303,92	0,00132 (4)
$ec_{5,0\ K}$	(As)	388,7916 (8)	0,0140 (5)

6 Main Production Modes

$Se - 74(n,\gamma)Se - 75$
$As - 75(d,2n)Se - 75$
$As - 75(p,n)Se - 75$

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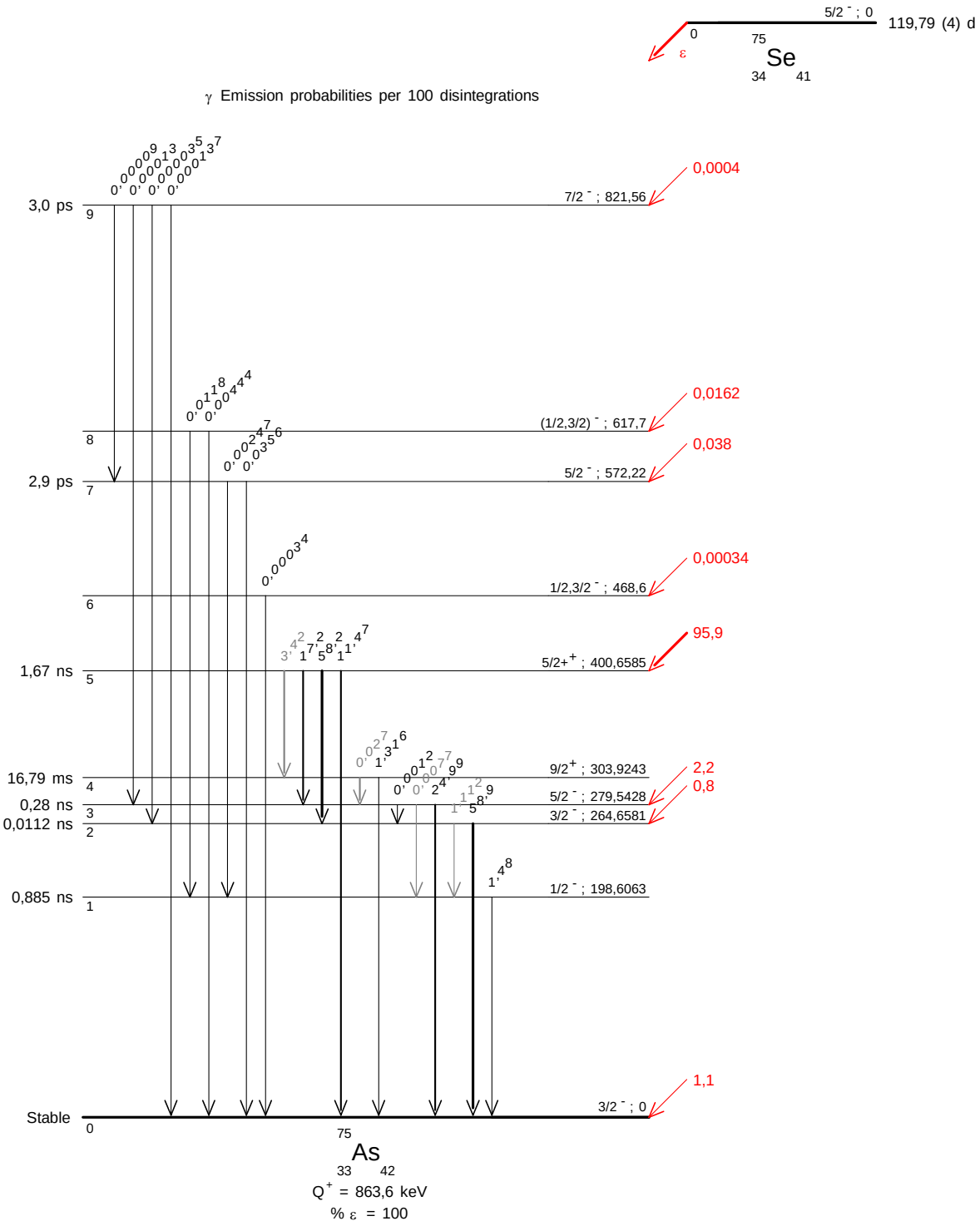
5/2 - ; 0
119,79 (4) d
0
75
Se
34 41
ε
γ Emission probabilities per 100 disintegrations
0,0004
7/2 - ; 821,56
3,0 ps
9
0,0162
(1/2,3/2) - ; 617,7
8
0,038
5/2 - ; 572,22
2,9 ps
7
0,00034
1/2,3/2 - ; 468,6
6
95,9
5/2+ ; 400,6585
1,67 ns
5
2,2
9/2+ ; 303,9243
16,79 ms
4
0,8
5/2 - ; 279,5428
0,28 ns
3
3/2 - ; 264,6581
0,0112 ns
2
1/2 - ; 198,6063
0,885 ns
1
1,1
3/2 - ; 0
Stable
0
75
As
33 42
Q+ = 863,6 keV
% ε = 100

^{75}Se - Comments on Evaluation of Decay Data by E. Browne and E. Schönfeld

Evaluation Procedures

We applied the *Limitation of Relative Statistical Weight* [1] (LWM) method for averaging numbers throughout this evaluation. The uncertainty assigned to the average value was always greater or equal than the smallest uncertainty of the values used to calculate the average.

Decay Scheme

^{75}Se decays 100% by electron capture to ^{75}As. We deduced from decay scheme a ground-state electron capture transition probability of 0.011 (5) (1.0 minus the sum of γ + conversion electron emission probabilities to the ground state). 76Hu11 reported an experimental limit of <0.012, with a 99% confidence level.

Since all of the observed gamma rays have been placed, the decay scheme is complete. Two additional levels at or barely below the ^{75}Se Q(EC)-value, which are populated in nuclear reactions, are worth mentioning (90Fa07). One at 859.9 (6) keV (1/2+), for which a possible (not observed) electron capture transition from ^{75}Se (5/2+) with a log *ft* > 11.0 (from systematic trends) would have a branching of ≤ 5.0x10^{-9}%. Another level reported at 864.8 (10) keV is more uncertain.

Nuclear Data

Table 1 shows measured half-life values. The recommended value, 119.79 (4) d, is the weighted average (LWM, χ^2/ν=2.45) of the input values shown in column 1, using the adjusted statistical weights given in column 4. Notice that the weight (0.99) in the value of 80Ho17 was reduced to 0.50. The weighted average, based on the unadjusted weights given in column 3, is 119.779 (6) (χ^2/ν=2.48). 75La16 reported a value of 118.450 (80) d, which has not been included in the average (authors recommended not to use their result).

Gamma Rays

Energies. Precise gamma-ray energies are from Helmer et al. [2]. These values are based on a revised energy scale that uses the new adjusted fundamental constants and wave lengths deduced from an updated value of the lattice spacing of Si crystals (Cohen and Taylor [3]). Helmer et al. [2] fitted the adjusted gamma-ray energies to a level scheme. Their recommended values are from level-energy differences. Less precise energies are from 77Pr08.

Emission Probabilities. We deduced the absolute photon emission probabilities given in Section 2.1 as follows:

First, by averaging (LWM) measured *relative* emission probabilities reported by 69Pa25, 71Pr07, 73SuZZ (for gamma rays with energies > 200 keV), 77Pr08, 77Ge12, 80Sc07, 83Yo03, 90Wa03, 90Me15, 92Sc09, 94Mi22, and thirteen measurements from the International Committee for Radionuclide Metrology (ICRM) inter comparison of relative gamma-ray emission probabilities in a Coordinated Research Program (CRP) (91BaZS). See Table 2.

Second, by using an absolute photon emission probability of 0.589 (3) for the 264-keV gamma ray to convert relative to *absolute* values.

All the values of the absolute emission probability of the 264-keV gamma ray were determined by 4π-βγ coincidence measurements. Because of the long half-life (17 ms) (compared to resolving time of the coincidence circuit) of the 303.9-keV level , the measurement missed events from the 24-keV transition. This effect can be corrected by using a factor equal to the absolute total (photons + electrons) emission

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probability of the 24-keV transition, plus one. We applied the *same* correction factor of 1.060 (5) to all the measurements, a weighted average (LWM) of the following experimental results:

0.055 (5)	Szörenyi et al., report to BIPM (1989), extended dead times comparable to the half-life of the isomeric state
0.065 (2)	90Ja15, correlation method
0.056 (2)	94Sm09, correlation method
0.058 (5)	94Ch56, double dead time method

Notice that the weighted average, 0.060 (5), is in perfect agreement with the recommended total absolute emission probability of the 24-keV transition (0.060 (4)) listed in Section 2.1.
The *corrected* values of the absolute photon emission probabilities of the 264-keV gamma rays are shown below:

0.5944 (83)	80Sc07
0.5796 (85)	83Yo03-1
0.5816 (85)	83Yo03-2
0.5955 (90)	87JeZZ
0.5903 (32)	94Mi22

The weighted average (LWM) of these values is 0.589 (3).

Conversion Coefficients.

We followed the following steps to determine *total* conversion coefficients:
1. Deduced an average K-electron emission probability for each electron line (See Table 3).
2. Deduced K-conversion coefficients from the K-electron emission probabilities mentioned above and the recommended photon emission probabilities given in Section 2.1. The electron and photon scales were normalized through the theoretical conversion coefficients for the 121- and 136-keV gamma rays, $\alpha_K(121)=0.0375$ and $\alpha_K=0.0265$, respectively.
3. Deduced multipolarities and mixing ratios (δ) for transitions with mixed mutipolarities from the K-conversion coefficients mentioned above, then combined these values with those of 77Kr13.
4. Deduced total conversion coefficients by interpolating theoretical (78Ro22) values for the recommended energies, multipolarities, and mixing ratios (See Table 4).
Multipolarities between brackets in Section 2.1 were not measured, but are those expected from the decay scheme.

Electron-Capture Transitions

EC transition energies are from Q_{EC}=863.6 (8) keV (93Au05) and the individual level energies. Transition probabilities (P_{EC}) (from transition probability balances at each level, unless otherwise specified) are given as branchings in percent (%) on the level scheme.
The electron-capture branching (0.9%, from transition probability balance) to the 303.9-keV level (9/2+) has a logft value of 8.3 that strongly disagrees with the systematic trend for second forbidden non-unique transitions (logft ≥ 11.0). This branching is determined by the probability balance of the 303.9-, 96.7-, and 24.4-keV gamma-ray transitions. The inaccuracy, however, may be due to the total (photons plus conversion electrons) emission probabilities of just the 96.7- and 24.4-keV transitions, and most likely, to that of the latter one. Using an electron-capture branching of 0.002% (logft = 11.0) and the recommended absolute emission probabilities and total conversion coefficients for the 303.9- and 96.7-keV transitions, one obtains a value of 5.1 (1)% for the total emission probability of the 24.2-keV transition. This value, which agrees (within 2σ) with the recommended *measured* emission probability of 6.0 (4)%, corresponds to a photon emission probability of 0.000228 (10) for the 24.4-keV gamma ray. The combined electron-capture branching to the 279.5- and 264.7-keV levels therefore increases to 3.0 (9)%. The 14.9-keV gamma ray between these levels has an unknown transition probability. For this reason, we can only deduce limits of

≥ 2.2% and ≤ 0.8% for the individual electron-capture branchings to the 279.5- and 264-7 keV levels, respectively. Fractional atomic shell electron-capture probabilities were calculated using data from 95ScXX.

Atomic Data

X-ray and Auger electron emission probabilities are values calculated with the computer program RADLST [4], using gamma-ray data from Section 2.1, electron-capture data from Section 2.4, and atomic data from 95ScZZ.

The measurement of K x-ray emission probabilities provided useful information to test the quality of our decay scheme. Measured values relative to 1.0 for Pγ(264) are given below.

0.940 (24)	66Ra09
0.91 (5)	74Ca29
0.903 (26)	70Pa25
0.931 (18)	92Sc09

The weighted average (LWM) of these values is 0.926 (18), and the corresponding absolute emission probability, 0.546 (11). This value compares with 0.565 (6), calculated with RADLST [4]. The agreement between these quantities constitutes a test for the self-consistency of the decay scheme.

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Table 2. ^{75}Se Measured Relative Gamma-Ray Emission Probabilities

Eγ(keV)	CRP-1	CRP-2	CRP-3	CRP-4	CRP-5	CRP-6	CRP-7	CRP-8	CRP-9	CRP-10
24,4	0.00045 (6)	0.00127 (12) *								0.00045 (6)
66.0	0.0185 (3)	0.0182 (6)	0.0176 (8)	0.0195 (6)		0.0178 (6)	0.0200 (17)	0.0186 (2)	0.0196 (4)	0.0191 (2)
80,9										
96,7	0.0593 (8)	0.0568 (15)	0.0613 (18)	0.0647 (18)		0.0541 (13)	0.0513 (30)	0.0579 (3)	0.0563 (5)	0.0591 (5)
121,1	0.2923 (15)	0.291 (6)	0.279 (6)	0.292 (4)	0.293 (5)	0.285 (5)	0.300 (10)	0.2865 (11)	0.2896 (14)	0.2916 (23)
136.0	0.999 (3)	0.963 (20)	0.946 (21)	0.999 (9)	0.999 (18)	0.959 (21)	0.995 (31)	0.982 (4)	0.999 (5)	0.997 (8)
198,6	0.02518 (13)	0.0252 (7)	0.0225 (8)	0.02568 (21)	0.0248 (5)	0.0238 (4)	0.0253 (7)	0.02509 (16)	0.02581 (12)	0.02534 (23)
249,2										
264,7	1.000 (4)	1.000 (21)	1.000 (22)	1.000 (11)	1.000 (15)	1.000 (17)	1.000 (26)	1.000 (5)	1.000 (4)	1.000 (8)
279,5	0.4253 (16)	0.439 (9)	0.422 (9)	0.421 (3)	0.426 (6)	0.424 (5)	0.426 (11)	0.4248 (23)	0.4236 (14)	0.425 (3)
303,9	0.02248 (9)	0.0225 (5)	0.0221 (6)	0.02091 (14)	0.0224 (4)	0.0223 (4)	0.0224 (6)	0.02234 (15)	0.02224 (8)	0.02242 (18)
373,5										
400,7	0.1927 (11)	0.197 (4)	0.191 (4)	0.1941 (12)	0.195 (3)	0.1917 (21)	0.195 (5)	0.1960 (10)	0.1979 (6)	0.1949 (16)
419,1	0.000206 (7)	0.00024 (9)				0.000102 (32)	0.000154 (10)			0.000196 (11)
468,6										
542,2										
556,4										
572,2	0.000602 (20)	0.000625 (22)				0.00058 (4)	0.00059 (3)	0.000610 (18)	0.000617 (14)	0.000610 (10)
617,7	0.000072 (7)	0.000067 (10)				0.000076 (6)	0.000080 (6)		0.000063 (6)	0.000078 (5)
821,6		0.000016 (12) *				3.0 E-06 (15)	0.000013 (7) *			

Eg(keV)	CRP-11	CRP-12	CRP-13	69Pa25	71Pr07	73SuZZ	77Pr08	77Ge12	80Sc07	83Yo03-1 [&]
24,4				0.00044 (6)			0.00065 (8)			
66.0	0.0194 (3)	0.0188 (2)	0.0195 (2)	0.0172 (4)		0.0097 (6) *	0.0146 (20)	0.0186 (9)	0.0193 (4)	
80,9				<0.001 *			0.00012 (4)			
96,7	0.0588 (6)	0.0583 (4)	0.0591 (5)	0.0512 (10)		0.047 (2) *	0.0522 (20)	0.059 (3)	0.0589 (13)	0.0578 (17)
121,1	0.2943 (22)	0.2931 (20)	0.2924 (20)	0.2770 (50)		0.254 (12) *	0.271 (40)	0.298 (9)	0.293 (3)	0.2924 (29)
136.0	1.004 (7)	1.012 (4)	0.994 (10)	0.950 (18)		0.903 (28) *	0.9546 (600)	1.02 (3)	0.998 (8)	0.992 (9)
198,6	0.02514 (20)	0.02586 (20)	0.0250 (3)	0.0238 (7)		0.025 (1) *	0.0248 (40)	0.0253 (8)	0.0249 (5)	0.0251 (4)
249,2							0.0000016 (4)			
264,7	1.000 (8)	1.000 (3)	1.000 (7)	1	1	1	1	1.00 (3)	1.000 (8)	1.000 (5)
279,5	0.424 (4)	0.4225 (8)	0.4269 (21)	0.420 (8)		0.425 (15)	0.426 (8)	0.424 (13)	0.426 (4)	0.4243 (20)
303,9	0.02220 (22)	0.02219 (16)	0.02239 (16)	0.0219 (7)		0.0220 (8)	0.0226 (40)	0.0221 (3)	0.0227 (2)	0.02234 (17)
373,5				<0.00006 *			0.000042 (4)			
400,7	0.1908 (17)	0.1936 (5)	0.1951 (10)	0.204 (5)		0.190 (6)	0.188 (6)	0.191 (3)	0.1956 (16)	0.1942 (13)
419,1	0.000217 (5)	0.000247 (26)		0.00023 (2)		0.000140 (16)	0.00018 (4)			0.000231 (21)
468,6				0.000010 (5) *	5.4 E-06 (18)		6.2 E-06 (10)			
542,2							2.2 E-06 (4)			
556,4							6 E-07 (2)			
572,2	0.000603 (7)	0.00067 (4)	0.00064 (3)	0.00063 (2)		0.00054 (3)	0.00050 (4)			0.000634 (29)
617,7	0.000077 (3)	0.000108 (23)		0.000075 (2)		0.000075 (31)	0.000062 (8)			0.000078 (21)
821,6					2.16 E-06 (10)		2.8 E-06 (2)			

Table 2. ^{75}Se Measured Relative Gamma-Ray Emission Probabilities (cont.)

Eγ(keV)	83Yo03-2 [&]	90Wa03	90Me15	92Sc09	94Mi22	Wgt. Avg. [#]	χ^2/ N−1	Rec. Value [@]
24,4			0.00046 (4)	0.000446 (20)		0.000456 (17)	1,25	0.000459 (20)
66.0		0.0196 (3)	0.0187 (1)	0.0191 (2)		0.01890 (11)	3,44	0.01888 (18)
80,9			0.00019 (4)			0.000134 (24)	1,36	0.00013 (3)
96,7		0.0591 (6)	0.0572 (21)	0.0591 (5)	0.0578 (3)	0.05807 (33)	6,1	0.05807 (33)
121,1	0.2912 (31)	0.2910 (31)	0.298 (2)	0.2916 (23)	0.2976 (11)	0.2920 (9)	3,72	0.2920 (56)
136.0	0.991 (13)	0.995 (10)	1.000 (3)	0.997 (8)	1.002 (3)	0.9983 (17)	2,38	0.989 (11)
198,6	0.0257 (4)	0.0250 (3)	0.0254 (2)	0.02534 (20)	0.0256 (2)	0.02537 (8)	2,57	0.0251 (7)
249,2						1.6 E-06 (4)		1.6 E-06 (4)
264,7	1.000 (6)	1.00 (1)	1.000 (5)	1.000 (8)	1.000 (3)	1.0000 (13)		1.000 (3)
279,5	0.4245 (24)	0.424 (5)	0.422 (4)	0.4247 (34)	0.4278 (12)	0.4243 (5)	0,82	0.4243 (8)
303,9	0.02226 (19)	0.0225 (3)	0.0223 (2)	0.02242 (18)	0.02238 (14)	0.02235 (4)	0,5	0.02235 (8)
373,5						4.2 E-05 (4)		4.2 E-05 (4)
400,7	0.1938 (12)	0.202 (2)	0.195 (3)	0.1949 (16)	0.1931 (7)	0.1947 (4)	3,2	0.1947 (11)
419,1	0.000198 (25)	0.000210 (3)	0.00018 (3)	0.000196 (12)		0.000198 (3)	6,09	0.000201 (5)
468,6						6.0 E-06 (8)	0.151	5.8 E-06 (13)
542,2						2.2 E-06 (4)		2.2 E-06 (4)
556,4						6.0 E-07 (20)		6.0 E-07 (20)
572,2	0.000651 (31)	0.000589 (7)	0.00060 (3)	0.000610 (10)		0.000604 (4)	1,67	0.000604 (7)
617,7	0.000073 (19)	0.000076 (2)	0.000077 (4)	0.000078 (5)		7.53E-05 (10)	0,7	7.53E-05 (20)
821,6			2.2 E-06 (2)			2.27 E-06 (14)	2,86	2.33 E-06 (17)

(#) Weighted average (largest of internal or external uncertainty). No adjustment of relative statistical weights.
(*) Discrepant (or not useful) data omitted from evaluation.
(&) Independent measurements reported by 83Yo03: Yoshizawa (83Yo03-1) and Katoh (83Yo03-2).
(@) Recommended value (LWM method). Adjusted relative statistical weights.

Table 4. ^{75}Se Conversion Coefficients

Eγ(keV)	Rec. I_K	Rec. Iγ	α_K(exp)[&]	Multp.	δ	δ[@]	Rec. δ [#]	α_K(theo.)*	α(theo.)*
24,4	3.1 E02 (3) L	0.000459 (20)	45 (5) L	M2+E3	0.051 (12)		0.051 (12)	45 (4) L	222 (9)
	1.25 E03 (15)		182 (24)					169 (4)	
66.0	82 (7)	0.01888 (18)	0.29 (3)	M1+E2	0.11 (6)	+0.18 (3)	+0.17 (3)	0.34 (3)	0.39 (4)
80,9	7 (1)	0.00013 (3)	3.6 (10)	[E2]				1.48 (4)	1.74 (5)
96,7	7.5 E02 (9)	0.05807 (33)	0.86 (11)	E2				0.773 (20)	0.898 (27)
121,1	168 (10)	0.2920 (56)	(0.0375) norm.	E1				0.0375 (10)	0.0422 (13)
136.0	389 (13)	0.989 (11)	(0.0265) norm.	E1				0.0265 (8)	0.0298 (9)
198,6	7.0 (3)	0.0251 (7)	0.0186 (11)	M1+E2	0.39 (5)		0.39 (5)	0.0186 (12)	0.0210 (14)
264,7	100 (2)	1.000 (3)	0.0067 (2)	M1+E2	0.16 (5)	-0.05 (1)	-0.11 (6)	0.0065 (3)	0.0073 (3)
279,5	53 (2)	0.4243 (8)	0.0083 (4)	M1+E2	0.60 (6)	-0.42 (1)	-0.51 (9)	0.0077 (6)	0.0087 (7)
303,9	15.9 (8)	0.02235 (8)	0.048 (3)	E3				0.0472 (14)	0.0542 (16)
400,7	3.7 (3)	0.1947 (11)	0.0013 (1)	E1				0.00122 (4)	0.00137 (4)
572,2	0.055 (22)	0.000604 (7)	0.0061 (24)	M1+E2		+0.43 (5)	+0.43 (5)	0.00109 (6)	0.00123 (8)

(&) From relative electron and gamma-ray emission probabilities in columns 2 and 3
(@) From γγ(Θ) (77Kr13)
(#) Recommended value deduced from results in columns 6 and 7
(*) Theoretical conversion coefficients from 78Ro22

Table 1. ^{75}Se Measured half-life values

1	119.6 (6)	Wright et al. (1957)
2	120.4 (2)	Easterday and Smith (1960)
3	119.779 (4)	Houtermans et al. (1980)
4	119.760 (50)	Schotzig et al. (1980)
5	119.800 (70)	Hoppes et al. (1982)
6	119.79 (4)	Recommended value

Table 3. ^{75}Se Relative Conversion Electron Intensities (I_K)

Eγ(keV)	55Sc09	59Me76	60De06	60Gr03	61Ed02	Rec. I_K
24,4				1250 (150)		1.25 E03 (15)
66.0			80 (12)	73.7 (44)	99 (12)	82 (7)
80,9			14 (13)	7 (1)		7 (1)
96,7			940 (60)	645 (25)	753 (60)	7.5 E02 (9)
121,1			180 (12)	154 (2)	187 (15)	168 (10)
136.0		377 (20)	450 (30)	384 (5)	378 (30)	389 (13)
198,6	6.4 (7)		6.8 (10)	7.3 (3)	7 (1)	7.0 (3)
264,7	100 (8)	100 (2)*	100 (2)*	100 (3)	100 (2)*	100 (2)
279,5	53 (7)	53.6 (16)	63 (5)	49.2 (30)	53 (5)	53 (2)
303,9	15.6 (13)	15.4 (9)	16 (1)	16.1 (8)	17.2 (17)	15.9 (8)
400,7	3.6 (6)	3.6 (4)	3.8 (3)	3.76 (26)	3.7 (4)	3.7 (3)
572,2				0.055 (22)		0.055 (22)

(*) Uncertainty estimated by evaluator.