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Summary Record of the 2<sup>nd</sup> meeting of the  
**WPEC Subgroup 25 on**

Validation of Fission Product Decay Data for Decay Heat Calculations

held in collaboration with IAEA as an  
IAEA Consultants' Meeting on Beta-decay and decay heat

OECD/NEA, Paris, France  
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**Abstract**

Participants at an IAEA Consultants' Meeting at IAEA Headquarters on 12-14 December 2005 debated the needs for additional decay data to be measured and entered in the various decay-data libraries for decay heat calculations. Specific recommendations and actions arose from this meeting in 2005, and were addressed further at another IAEA Consultants' Meeting on 3 May 2006 prior to a full meeting of the OECD/NEA Working Party on International Nuclear Data Evaluation Cooperation (WPEC). Decay-data requirements were reviewed during the course of the discussions, and a relatively comprehensive list of radionuclides was prepared to be recommended for TAGS measurements (total absorption gamma-ray spectroscopy). This meeting was organized in collaboration with the OECD/NEA Data Bank through Subgroup 25 of the WPEC.

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## 1. INTRODUCTION

A previous IAEA Consultants' Meeting held in Vienna on 12 to 14 December 2005 resulted in discussions on the suitability and completeness of various national and international decay-data libraries for decay heat calculations [1]. These nuclear applications libraries include JEFF-3.1, JENDL-FPDD and a preliminary version of ENDF/B-VII. Quantitative studies and confident predictions of the resulting decay heat from post-irradiated nuclear fuel are extremely important for the safe and economic operation of nuclear power plants and subsequent fuel element storage and processing. A significant amount of nuclear data needs to be known with sound estimates of their uncertainties: neutron cross-sections, fission yields and decay data (fission products and actinides – half-lives, and mean light-particle (beta) and electromagnetic (gamma) energies).

Prior to reporting to the OECD/NEA Working Party on International Nuclear Data Evaluation Cooperation (WPEC) on 4-5 May 2006, Subgroup 25 of the WPEC held a one-day meeting at the NEA Data Bank, Paris, in collaboration with the IAEA Nuclear Data Section, to review their analyses of the decay data needs for decay heat calculations (Appendix 1). A primary aim was to initiate actions to produce a well-defined list of fission-product radionuclides for future TAGS measurements (total absorption gamma-ray spectroscopy) in order to assist and guide experimentalists.

Participants elected Dr. T. Yoshida as Chairman, and A.L. Nichols as Secretary for the meeting. The provisional agenda was accepted as appropriate (Appendix 2). Apologies for absence were received from Berta Rubio (IFIC, Valencia, Spain) and Mark Kellett (IAEA Nuclear Data Section).

## 2. PREVIOUS MEETING AND ACTIONS ARISING

The minutes of the Consultants' Meeting on 12-14 December 2005 were accepted as a true record of events without any corrections or modifications.

### 2.1. Actions

2.1.1. Understand and resolve some of the discrepancies between libraries – Bersillon/Yoshida/Kellett/Sonzogni by May 2006.

While some specific features of these discrepancies had been satisfactorily addressed by Bersillon ( $^{89}\text{Sr}$ ,  $^{96}\text{Sr}$ ), much remained unresolved as noted in a paper prepared by Bersillon, January 2006 ("Some comments on the discrepancies between libraries for the nuclei of the first list"). Some debate concerning these nuclides occurred during the course of this second meeting, but actions still remain with Nichols ( $^{87}\text{Br}$ ), Yoshida ( $^{92}\text{Rb}$ ,  $^{96}\text{Y}$ ,  $^{98}\text{Nb}$ ,  $^{102}\text{Tc}$ ,  $^{135}\text{Te}$  and  $^{142}\text{Cs}$ ) and Bersillon ( $^{97}\text{Sr}$ ) concerning the justification for these individual radionuclides to be recommended for TAGS measurements.

ACTION remains.

2.1.2. Identify any additional decay heat measurements from Japan – Yoshida by end-January 2006.

ACTION completed:  $^{235}\text{U}$  and  $^{237}\text{Np}$  measurements on Yayoi.

2.1.3. Provide comprehensive list of decay heat measurements – Mills by end-January 2006.

ACTION completed (including provision of Tobias data).

Concern was expressed with respect to the discrepancies between ORNL decay heat benchmark data [2] and other such data sets at cooling times beyond 1,000 secs.

ACTION: Ian Gould (ORNL) to determine the extent of this disagreement of the ORNL decay heat measurements of Dickens et al. [2] with other earlier studies, and issue a statement concerning data validity.

2.1.4. Introduce requests for required TAGS measurements in NEA High Priority Request List – Henriksson.

ACTION still on-going – dependent on agreed output from this meeting.

2.1.5. Contact Idaho National Laboratory (INL) to obtain raw TAGS data of Greenwood et al. [3] – Songzogni by end-January 2006.

ACTION withdrawn – raw TAGS data of Greenwood et al. are unavailable.

2.1.6. Undertake analyses of INL TAGS data (if available) – negated by unavailability of data.

2.1.7. Undertake detailed comparisons of INL TAGS radionuclides (JENDL-FPDD, JEFF-3.1 and INL TAGS) – Kellett and Yoshida by end-March 2006.

ACTION completed by Bersillon.

2.1.8. Contact laboratories where TAGS measurements might be undertaken – Gelletly et al. by end-January 2006.

ACTION completed – studies continue at the University of Jyväskylä, Finland, and are envisaged at IPN-Orsay, France.

2.1.9. Convene meeting of representatives from industry, laboratory managers and experimenters to resolve manpower and resource issues – Gelletly et al. by mid-2006.

ACTION on-going – meeting has now been scheduled for 17 July 2006 at IPN-Orsay (proposed measurements planned on ALTO facility at IPN-Orsay).

2.1.10 Undertake TAGS measurements of a small number of key nuclides at existing facilities – Gelletly et al.

ACTION on-going – see Section 3.6.

2.1.11. Organise inclusion of the Greenwood et al. (and other TAGS) data into an appropriate database – Henriksson et al.

ACTION on-going - create a TAGS database as data become available (but INL TAGS data are unavailable (see above) – continue action with any other TAGS data).

### **3. Presentations**

#### **3.1. Decay heat calculations with preliminary ENDF/B-VII library (A. Songzogni, NNDC, Brookhaven National Laboratory, USA).**

The TAGS measurements of Greenwood et al. [3] have been introduced into ENSDF, and the resulting decay-data file used to calculate the total, beta and gamma energy components of the decay heat for various fissioning actinides ( $^{235}\text{U}$  and  $^{239}\text{Pu}$ ). These data were compared with the recommended Tobias decay-heat data [4, 5]. Songzogni noted that the new decay database will be adopted in the US ENDF/B-VII library, and included the following new features:

- (a) used BrICC internal conversion coefficients (Kibedi et al. analyses of Band and Raman model [6]);
- (b) mean beta energies for a number of 2<sup>nd</sup> forbidden non-unique transitions (not relevant to decay heat calculations);
- (c) half-life values from Möller 1997 for some fission products below T<sub>1/2</sub> of 1 sec [7].

Sonzogni also intends improving the X-ray and Auger-electron data of this library.

Sensitivity studies included increasing the electromagnetic energy component by 50%, and decreasing the light-particle energy component by 50%. A check was made of the main contributors to the electromagnetic decay heat with respect to their Q-values, known/unknown decay scheme, and possible presence of the pandemonium effect (lack of valid gamma-ray data), along with TAGS measurements having been/not been performed at INL. This exercise generated two priority lists of radionuclides that have incomplete decay schemes and/or evidence of pandemonium (for <sup>235</sup>U and <sup>239</sup>Pu fission) – these fission-product nuclides were introduced into the provisional tabulation of “Radionuclides recommended for TAGS measurements” (Table 2 of INDC(NDS)-0483, January 2006).

### **3.2. Decay heat calculations with JEFF-3.1 library (R.W. Mills, Nexia Solutions, BNFL, UK).**

Mills stressed the importance of decay heat calculations for the safe handling of spent nuclear fuel from the point of view of transport, storage and reprocessing. Validation is also required for short cooling times in terms of the total, beta (light particle) and gamma (electromagnetic) decay heat and their uncertainties.

Decay heat calculations have been carried out for <sup>235</sup>, <sup>238</sup>U and <sup>239</sup>, <sup>241</sup>Pu thermal neutron-induced fission pulses based on various JEF decay data libraries (JEF-1, JEF-2.2 and JEFF-3.1) and the FISPIN inventory code. The majority of these data sets exhibit calculation/experiment (C/E) ratios that vary by factors of -0.8 to +1.15 over a cooling time of 10<sup>5</sup> secs (most significant C/E deviations occur with the <sup>239</sup>Pu beta and gamma decay components).

### **3.3. Assessment of TAGS data on the gamma decay heat for <sup>235</sup>U and <sup>239</sup>Pu with JEFF-3.1 (C.J. Dean, Serco Assurance, Winfrith, UK).**

The gamma contributions to decay heat in fission pulses on <sup>235</sup>U and <sup>239</sup>Pu have been studied over 1 to 10<sup>4</sup> secs (2.8 hours). These calculations involved a number of important variations:

- (a) predictions using mean gamma energies from Greenwood et al. (TAGS) [3];
- (b) predictions using mean gamma energies from Rudstam;

and their comparison with Tobias’ standards [4, 5], and the recent measurements at Lowell, Yayoi and ORNL. The Tobias decay heat standards are based on least-squares fits to fifty-four <sup>235</sup>U and twenty-eight <sup>239</sup>Pu measurements. Dean noted that UK and Japanese decay heat calculations involve the adoption of thermal fission yields for both thermal and fast spectral studies, while French studies are based on fast yields for fast reactors and thermal yields for thermal reactors.

Important observations include the following:

- (a) introduction of Rudstam mean gamma energies [8] for important radionuclides without discrete emission data exhibits no improvement over JEFF-3.1;
- (b) introduction of the existing TAGS mean gamma energies of Greenwood et al. [3] shows a significant improvement relative to JEFF-3.1 for both <sup>235</sup>U and <sup>239</sup>Pu, particularly for cooling times from 20 to 200 secs;

- (c) calculations tend to underpredict decay heat relative to benchmark experiments;
- (d) Tobias' standards data are generally higher than the experimental data up to  $\approx 100$  secs [4, 5].

### **3.4. Remarks on decay heat calculations (O. Bersillon, CEA Bruyères-le-Châtel, France).**

Bersillon reported on comparisons of JEFF-3.1 with JENDL-FPDD decay data files. Q-values in these two libraries can differ by as much as 40%, despite the known similarities over the previous 15 years between these data for the nuclides of greatest interest in the Audi and Wapstra atomic mass tables. The most up to date atomic mass tables should be used (AME2003) in the various decay data libraries [9], and such adoptions impact directly on the energies of the individual beta transitions that would need to be adjusted in the files. Comparisons had also been made between the equivalent Rudstam and Greenwood et al. data, which were found to exhibit differences of 20 to 25% in their mean beta energies. Bersillon noted significant differences in the mean energy data for both  $^{140}\text{Cs}$  and  $^{144}\text{La}$  that could be resolved by TAGS. In particular,  $^{144}\text{La}$  would appear to possess an extremely complex decay scheme that could be better addressed by adopting the TAGS data of Greenwood et al. [3].

After some debate, participants agreed that specific issues noted by Bersillon in January 2006 need to be addressed by individual participants (Bersillon, Nichols and Yoshida), as specified in Section 2.1.1.

### **3.5. Assessment of TAGS measurements from studies of JENDL-FPDD and JEFF-3.1 data libraries (T. Yoshida, Musashi Institute of Technology, Japan).**

Decay heat calculations of the gamma (electromagnetic) component after a fission pulse in  $^{239}\text{Pu}$  were used to study the impact of introducing the Greenwood et al. TAGS data into JENDL-FPDD and JEFF-3.1. While these modifications to the JEFF-3.1 library improved the fit of the resulting decay heat calculations towards the benchmark measurements, the same additions to JENDL-FPDD resulted in significant deviations from these same integral data. Yoshida was able to use these calculations and a knowledge of the half-lives, Q-values of the various fission products and the following criteria to produce a list of radionuclides that merit TAGS studies:

- (a) contribution to the difference between JEFF-3.1 and JENDL-FPDD is greater than 1% of the total difference in the beta and gamma decay-heat components;
- (b) highest evaluated nuclear level is less than 70% of the known Q-value.

The resulting list of radionuclides included high priority  $^{98, 101}\text{Nb}$  and  $^{102, 104, 105}\text{TC}$ ; and medium priority  $^{100}\text{Zr}$ ,  $^{99, 102}\text{Nb}$ ,  $^{103, 105}\text{Mo}$  and  $^{103, 106, 107}\text{Tc}$ . These radionuclides were introduced into the provisional tabulation of "Radionuclides recommended for TAGS measurements" (Table 2 of INDC(NDS)-0483, January 2006).

### **3.6. TAGS experimental status**

Gelletly (University of Surrey, UK) queried the emphasis on TAGS measurements. All participants agreed that an ideal resolution of current decay-data issues would also have to include well-defined decay schemes derived from high-resolution gamma-ray spectroscopy. Nevertheless, reliable mean decay data are sufficient for the resolution of decay heat issues. On this basis, TAGS measurements of the important fission-product nuclides are critical in design and safety assessments of advanced reactor systems such as Generation-IV and beyond.

Tain (IFIC, Spain) summarized on-going negotiations with experimental research institutes that possess or are planning to assemble facilities suitable for TAGS studies. The ALTO facility is in the process of being designed and assembled at IPN-Orsay – this apparatus should become available within 2 years, and has the capability of studying refractory radionuclides which is an important feature with respect to specific fission

products of interest (Nb, Tc and Mo). One envisaged problem will be any request to study radionuclides that undergo delayed neutron emission; consideration is being given to such nuclides in order to avoid possible errors in any TAGS measurements (DESPEC).

Algora (IFIC, Spain) described recent TAGS measurements at the University of Jyväskylä that focused on  $^{102, 104, 105}\text{Tc}$ . Difficulties had been experienced with preparing the  $^{102}\text{Tc}$  source, but he was in the process of analysing the  $^{104, 105}\text{Tc}$  data to produce mean beta and gamma energies. A new proposal had also been prepared to undertake further measurements at the University of Jyväskylä:

		$Q_{\beta}$ (keV)	$T_{1/2}$ (secs)
$^{102}\text{Tc}$	$\rightarrow$ $^{102}\text{Ru}$	4532	5.28
$^{103}\text{Tc}$	$\rightarrow$ $^{103}\text{Ru}$	2662	54.2
$^{103}\text{Mo}$	$\rightarrow$ $^{103}\text{Tc}$	3750	67.5
$^{105}\text{Mo}$	$\rightarrow$ $^{105}\text{Tc}$	4950	35.6
$^{106}\text{Tc}$	$\rightarrow$ $^{106}\text{Ru}$	6547	35.6

and possibly  $^{98, 101}\text{Nb}$  and  $^{107}\text{Tc}$ . A laser ionization process is required to produce “clean” isotopic sources.

Additional discussion included the identification of suitable journals for the publication of TAGS data directed towards the resolution of decay-heat calculations for nuclear power plant: *Phys. Rev. C, Nucl. Sci. Eng., Nucl. Instrum. Meth. Phys. Res. A or B* and *Appl. Radiat. Isot.*

#### 4. CONCLUDING REMARKS

Various presentations at the two Consultants’ Meetings have assisted greatly in the assembly of a list of radionuclides recommended for TAGS measurements (Table 1). This list has been refined over the previous 5 months, but still requires further analysis and clarification as indicated in the comments column. Comparisons between the relevant files in JENDL-FPDD and JEFF-3.1 (and ENDF/B-VII) are particularly important, and need to be made as soon as possible, particularly with respect to identifying the origins of the mean energy data in the specific JENDL-FPDD files. All actions that arose from the meeting on 3 May 2006 or remain outstanding from December 2005 are listed in Appendix 3.

Good progress is being made in the identification of suitable TAGS facilities in Europe. The plans for ALTO at IPN-Orsay represent an exciting opportunity for undertaking TAGS for some of the more refractory radionuclides to be found in Table 1. Full support should be given by Subgroup 25 and WPEC to the experimental team as they begin negotiations with the management of the IPN-Orsay facility.

A report was prepared for the main WPEC meeting under the authorship of T. Yoshida as coordinator of Subgroup 25 (Appendix 4). This report covered the work undertaken over the previous 12 months, and included both Consultants’ Meetings in December 2005 and May 2006. No further Consultants’ Meetings are envisaged within the terms of reference of Subgroup 25. Rather, a final report will be prepared before the end of calendar year 2006 for submission to WPEC, recommending a well-defined list of fission-product radionuclides for TAGS measurements in order to improve decay heat calculations without resorting to theory. Progress made by the experimentalists over 2006-2008 will be monitored by staff of the IAEA Nuclear Data Section, and further meetings are envisaged after the IPN-Orsay studies have begun, hopefully in approximately 2 years time.

Table 1: Requested TAGS Measurements.

Radionuclide	Priority	$Q_{\beta}$ -value (keV)	Half-life	Comments
35-Br-86	1	7626(11)	55.1 s	
35-Br-87	1	6852(18)	55.65 s	Extremely complex decay scheme with substantial gamma component - large uncertainties in the mean gamma energy arises from significant disagreements between the various discrete gamma-ray measurements. Also ( $\beta^-$ , n) branch.
35-Br-88	1	8960(40)	16.36 s	( $\beta^-$ , n) branch.
36-Kr-89	1	4990(50)	3.15 min	Incomplete decay scheme
36-Kr-90	1	4392(17)	32.32 s	Incomplete decay scheme
37-Rb-90m	2	6690(15)	258 s	Repeat of INL TAGS measurement – data check.
37-Rb-92	??	8096(6)	4.49 s	[see Action table] Small ( $\beta^-$ , n) branch.
38-Sr-89	??	1493(3)	50.53 d	[see Action table]
38-Sr-97	2	7470(16)	0.429 s	Extremely short half-life (0.429 s), and possible ( $\beta^-$ , n) branch.
39-Y-96	??	7096(23)	5.34 s	[see Action table]
40-Zr-99	3	4558(15)	2.1 s	
40-Zr-100	2	3335(25)	7.1 s	
41-Nb-98	1	4583(5)	2.86 s	
41-Nb-99	1	3639(13)	15.0 s	
41-Nb-100	1	6245(25)	1.5 s	
41-Nb-101	1	4569(18)	7.1 s	
41-Nb-102	2	7210(40)	1.3 s	
42-Mo-103	1	3750(60)	67.5 s	
42-Mo-105	1	4950(50)	35.6 s	
43-Tc-102	1	4532(9)	5.28 s	
43-Tc-103	1	2662(10)	54.2 s	
43-Tc-104	??	5600(50)	18.3 min	[see Action table]
43-Tc-105	??	3640(60)	7.6 min	[see Action table]
43-Tc-106	1	6547(11)	35.6 s	
43-Tc-107	2	4820(90)	21.2 s	
51-Sb-132	1	5509(14)	2.79 min	
52-Te-135	2	5960(90)	19.0 s	
53-I-136	1	6930(50)	83.4 s	Incomplete decay scheme
53-I-136m	1	7580(120)	46.9 s	
53-I-137	1	5877(27)	24.13 s	( $\beta^-$ , n) branch.
54-Xe-137	1	4166(7)	3.82 min	Incomplete decay scheme
54-Xe-139	1	5057(21)	39.68 s	
54-Xe-140	1	4060(60)	13.6 s	
55-Cs-142	??	7308(11)	1.69 s	[see Action table] ( $\beta^-$ , n) branch.
56-Ba-145	2	5570(110)	4.31 s	Repeat of INL TAGS measurement – data check.
57-La-143	2	3425(15)	14.2 min	Repeat of INL TAGS measurement – data check.
57-La-145	2	4110(80)	24.8 s	Repeat of INL TAGS measurement – data check.

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*Consultants' Meeting (CM) on*

***Beta-decay and decay heat***

held in collaboration with WPEC Subgroup 25  
 Validation of Fission Product Decay Data for Decay Heat Calculations  
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International Atomic Energy Agency

**Consultants' Meeting (CM) on**

***Beta-decay and decay heat***

held in collaboration with WPEC Subgroup 25

Validation of Fission Product Decay Data for Decay Heat Calculations

OECD/NEA, Paris, France

3 May 2006, 09:00 – 18:00

## **AGENDA**

1. Welcome and practical matters
2. Approval of the Agenda
3. Approval of the summary record from the last meeting held at the IAEA as a Consultants' Meeting on Beta-decay and decay heat, December 2005
4. Review of Actions
5. Status of database studies and the experimental facilities for new measurements
6. Review of recommendations and new actions
7. Any other business
8. Date and place for the next meeting

## LISTS OF ACTIONS:

Actions related to Bersillon paper: “Some comments on the discrepancies between libraries for the nuclei of the first list” Olivier Bersillon, January 2006 – (“first list” is Table 2 of INDC(NDS)-0483, January 2006).

Nuclide	Comments	Action
<sup>87</sup> Br	(a) 10% difference in $E_\gamma$ between JEFF-3.1 and JENDL-3.* (b) $E_\gamma = 3087 \pm 771$ keV in JEFF-3.1 (UKPADD-6.4), while $E_\gamma = 3340$ keV with no uncertainty in JENDL-3.2.* Large uncertainty of 25% is difficult to understand in UKPADD.	A.L. Nichols
<sup>92</sup> Rb	Large differences in $E_\beta$ and $E_\gamma$ between JENDL-3.2* and JEFF-3.1 (from ENSDF). $E_\gamma$ for JENDL-3.2* appears to be abnormally small.	T. Yoshida
<sup>89</sup> Sr	$E_\beta = 585 \pm 234$ keV and $E_\gamma$ close to zero in JEFF-3.1 (LNHB).	O. Bersillon
<sup>97</sup> Sr	$E_\beta$ and $E_\gamma$ in JEFF-3.1 come from NUBASE ( $E_\beta = E_\gamma = Q_\beta/3 = 2456$ keV), and are in good agreement with Rudstam values. Adopt Rudstam uncertainties?	O. Bersillon
<sup>96</sup> Y	(a) JEFF-3.1 (from ENSDF) recommends $\beta$ -transition to the daughter ground state of 95.5%, which is compatible with the low $E_\gamma$ in JEFF but not the high $E_\gamma$ in JENDL-3.2.* (b) Check $\beta$ intensities and their origins in ENSDF; re-assess data in JENDL-3.2.*	O. Bersillon T. Yoshida
<sup>98</sup> Nb	JEFF-3.1 and JENDL-3.2* data have origins in ENSDF, but they exhibit significant differences in $E_\beta$ and $E_\gamma$ . Does this arise from Gross Beta Theory input in JENDL-3.2?	T. Yoshida
<sup>102</sup> Tc	Same as <sup>98</sup> Nb.	T. Yoshida
<sup>104</sup> Tc	JEFF-3.1 data exhibit a good energy balance, and originate from ENSDF. Why are TAGS measurements required?	T. Yoshida
<sup>105</sup> Tc	Same as <sup>104</sup> Tc.	T. Yoshida
<sup>135</sup> Te	Same as <sup>98</sup> Nb.	T. Yoshida
<sup>142</sup> Cs	(a) Decay scheme is well-defined, and the pandemonium effect should not be large. (b) $E_\gamma = 675$ keV in JEFF-3.1 (from ENSDF), while $E_\gamma = 1787$ keV in JENDL-3.2.* (c) Reconsider the JENDL-3.2* evaluation – update, and assess the need for Gross Beta Theory input.	T. Yoshida
<sup>145</sup> Ba	Energy balance is very poor due to problems in quantifying $\beta$ feeding – new evaluation is merited.	ENSDF evaluator
<sup>143</sup> La	Same as <sup>145</sup> Ba.	ENSDF evaluator
<sup>145</sup> La	Same as <sup>98</sup> Nb.	T. Yoshida

\* JENDL-3 and JENDL-3.2 are the same library (referred to generically as JENDL-FPDD in the text of the minutes).

## ACTIONS

Action	Responsible Member	Deadline	Status
Introduce requests for required TAGS measurements in NEA High Priority Request List.	Henriksson	when appropriate	Dependent on the output from participants of this Subgroup (still on-going).
Convene meeting of representatives from industry, laboratory managers and experimenters to resolve manpower and resource issues.	Gelletly	mid-July 2006	Meeting scheduled for 17 July 2006 at IPN-Orsay.
Undertake TAGS measurements of a small number of key nuclides (e.g., 43-Tc-102, 56-Ba-145, 57-La-143, -145) at existing facilities.	Algora/Tain		On-going (see Section 3.6).
Organise inclusion of the Greenwood <i>et al.</i> and other TAGS data into an appropriate database.	Henriksson	when appropriate	Preparation of such a database is long term (Greenwood <i>et al.</i> data are unavailable) – will assemble other TAGS data as they become available.
Determine the extent of the disagreement of the ORNL decay heat measurements of Dickens <i>et al.</i> with earlier studies (cooling times beyond 1,000 secs).	Gould	September 2006	

### WPEC Sub-group 25: Validation of Fission Product Decay Data for Decay Heat Calculations

Report to WPEC, May 2006

T. Yoshida (Sub-group Coordinator)  
Musashi Institute of Technology, Tokyo

#### 1. Kick-off Meeting at Vienna

An IAEA Consultants' Meeting on "Beta-decay and decay heat" was held at IAEA Headquarters on 12-14 December 2005, as a kick-off meeting for the joint effort of the decay-heat specialists and the TAGS measurement group. All the second-day participants among those listed in the Appendix agreed to join WPEC Subgroup 25, followed by a further participation of three Japanese scientists. The summary report of this meeting was prepared by A.L. Nichols as INDC(NDS)-0483.

#### 2. Recommendations and Actions from the Vienna Meeting

(1) Discrepancies between existing 21st century libraries. Assessment is required to understand precisely the nature of individual differences between JENDL-FPDD-2000 and JEFF-3.1.

(2) Provisional list of nuclides to be studied using TAGS

It is required to identify the nuclides worthy of new TAGS measurements, in part through the action (1).

(3) Experimental studies

Participants believe that accurate measurements of the average beta- and gamma-energies can be made by means of the TAGS technique. Measurements of ground state transitions are also essential. Though existing experimental facilities should be used for some particular cases, a dedicated facility should be setup at a particular accelerator where sufficient beam time can be devoted to these measurements in a systematic way.

(4) Library of TAGS data

Data derived from TAGS should be collected and recorded so that proper use can be made of the TAGS results. The contents of this new database should be made widely available, and should not be restricted to decay heat applications.

#### 3. Second Meeting

A second SG25/Consultants' Meeting on "Beta-decay and decay heat" was held on 3 May 2006 at the NEA Headquarters, Issy-les-Moulineaux, France, in advance of the annual WPEC meeting. All relevant decay databases and decay heat analyses were re-assessed, and actions were agreed to complete this particular aspect of the work in preparation for a definitive list of fission-product radionuclides for TAGS measurements. The provisional list of TAGS radionuclides has increased further to approaching 35-40 (from the original (and now consolidated) list of 15 radionuclides).

Proposed measurement facilities were described, including plans for TAGS studies at IPN-Orsay. Further discussions are required to solicit full support and agreement by IPN-Orsay personnel (to use ALTO facility).

No further SG meetings are envisaged at this time – a final table of recommended radionuclides for TAGS will be agreed on the basis of the two meetings, and a SG report will be produced before the end of 2006.

## APPENDIX

### LISTS OF PARTICIPANTS

IAEA Consultants' Meeting *Beta-decay and decay heat* at Vienna, 12-14 December 2005

ALGORA, Alejandro	Institute de Fisica Corpuscular, Valencia
BERSILLON, Olivier	CEA/DAM, Bruyères-le-Châtel
GELLETTY, William	University of Surrey, Guilford, Surrey
HENRIKSSON, Hans	NEA Data Bank, Issy-les-Moulineaux
JACQMIN, Robert*	CEA/DER, SPRC, Cadarache
KELLETT, Mark A.	IAEA Nuclear Data Section, Vienna
MENGONI, Alberto*	IAEA Nuclear Data Section, Vienna
NICHOLS, Alan L.	IAEA Nuclear Data Section, Vienna
RUBIO, Berta	Institute de Fisica Corpuscular, Valencia
SONZOGNI, Alejandro	NNDC, Brookhaven National Laboratory, Upton
TAIN, Jose Luis	Institute de Fisica Corpuscular, Valencia
YOSHIDA, Tadashi	Musashi Institute of Technology, Tokyo

\* Attended only on the first day as advisers/observers

SG25/CM *Beta-decay and decay heat* at NEA Data Bank, 3 May 2006, additional:

GOULD, Ian	ORNL (represented by DUNN, M)
KATAKURA, Jun-ichi	Nuclear Data Center, JAEA, Tokai
MILLS, Robert	Nexia Solutions, Sellafield
DEAN, Christopher	Serco Assurance, Winfrith

Other SG25 participants:

OYAMATSU, Kazuhiro	Aichi Shukutoku University, Nagoya
TACHIBANA, Takahiro	Waseda University, Tokyo
ROQUE, Benedicte	CEA/DER, SPRC, Cadarache