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## BURNUP CREDIT CRITICALITY BENCHMARK

# ANALYSIS OF PHASE II-B RESULTS: CONCEPTUAL PWR SPENT FUEL TRANSPORTATION CASK

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RESUME : profil axial of (Phase II-B) cas de bas étudiés son combustible de fissions zones hom résultats pa De bons ac	<b>RESUME</b> : Le groupe de travail « Burnup Credit Criticality Benchmark » de l'OCDE/AEN a étudié l'effet du profil axial du taux de combustion sur la criticité d'un emballage de transport d'assemblages REP irradiés (Phase II-B). Les résultats finaux de ce benchmark sont présentés et analysés dans le présent rapport. Neuf cas de base et deux configurations accidentelles complémentaires ont été considérés. Les paramètres étudiés sont : le taux de combustion (0 GWj/t dans le cas du combustible neuf, 30 et 50 GWj/t dans le cas du combustible irradié), la composition du combustible (selon que celle-ci comprend les actinides et les produits de fissions ou les actinides uniquement), la description du profil axial du taux de combustion (une ou neuf zones homogènes). Au total, quatorze participants appartenant à sept pays différents ont soumis des résultats partiels ou complets (keff et taux de fission).						
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### RÉSUMÉ

Le groupe de travail « Burn-up Credit Criticality Benchmark » de l'OCDE/AEN a étudié l'effet du profil axial du taux de combustion sur la criticité d'un emballage de transport d'assemblages REP irradiés (Phase II-B). Les résultats finaux de ce benchmark sont présentés et analysés dans le présent rapport.

Neuf cas de base et deux configurations accidentelles complémentaires ont été considérés. Les paramètres étudiés sont : le taux de combustion (0 GWj/t dans le cas du combustible neuf, 30 et 50 GWj/t dans le cas du combustible irradié), la composition du combustible (selon que celle-ci comprend les actinides et les produits de fissions ou les actinides uniquement), la description du profil axial du taux de combustion (une ou neuf zones homogènes). Au total, quatorze participants appartenant à sept pays différents ont soumis des résultats partiels ou complets (k<sub>eff</sub> et taux de fission).

De bons accords ont été obtenus entre les  $k_{eff}$  calculés par les participants. La dispersion des résultats, caractérisée par 2  $\sigma_r$  (où  $\sigma_r$  est l'écart-type divisé par la valeur moyenne) variait entre 0,5 % et 1,1 % pour les cas avec un combustible irradié et valait 1,3 % pour le cas avec un combustible neuf. L'effet en réactivité du profil axial de taux de combustion dans les cas de base était similaire à celui obtenu dans la phase II-A : moins de 1000 pcm en valeur absolue pour les cas où le taux de combustion est inférieur ou égal à 30 GWj/t ou pour les cas sans produits de fission et de l'ordre de -4000 pcm pour le cas à 50 GWj/t avec les produits de fission. Ceci étant, l'étude des deux configurations accidentelles a mis en évidence que l'effet en réactivité de la discrétisation axiale du taux combustion dépendait de la configuration géométrique étudiée. En effet pour ces configurations accidentelles, l'approximation du taux de combustion axialement uniforme a été trouvée non conservatoire même pour de faibles valeurs du taux de combustion (10 GWj/t) et sans les produits de fission ; l'effet en réactivité du profil axial du taux de combustion atteignait -14000 pcm dans le cas où le taux de combustion est 50 GWj/t et où la composition inclut les produits de fission.

Le calcul des fractions et des densités de fission a également été considéré. L'analyse a mis en évidence des problèmes de convergence des sources dans les cas où le profil axial du taux de combustion est décrit.

Mots-clé : Criticité, Taux de combustion, Assemblages REP, Emballage de transport, Profil axial du taux de combustion, Convergence des sources

#### SUMMARY

The OECD/NEA "Burn-up Credit Criticality Benchmark" working group has studied the effect of axial burn-up profile on the criticality of a realistic PWR spent fuel transport cask (Phase II-B). The final results of this benchmark are presented and analysed in this report.

Nine basic cases and two additional accident configurations were considered with the following varying parameters: burn-up (0 GWd/t for fresh fuel, 30 and 50 GWd/t), fuel composition (actinides only and actinides with fifteen fission products), axial burn-up discretisation (1 or 9 zones). In all, fourteen participants from seven different countries submitted partial or complete results (multiplication factors, fission reaction rates).

Good agreement was found between participants for calculated  $k_{eff}$ . The dispersion of results, characterised by 2  $\sigma_r$  (where  $\sigma_r$  is the ratio between the standard deviation and the average value) ranged from 0.5% to 1.1% for irradiated fuels and was equal to 1.3% for fresh fuel. The reactivity effect of axial burn-up profile for basic cases was similar to that obtained in Phase II-A: less than 1000 pcm for cases with burn-up less than or equal to 30 GWd/t or for cases without fission products and about -4000 pcm for 50 GWd/t burn-up and composition including fission products. However, two accident cases highlighted that the reactivity effect of axial burn-up discretisation depends on the configuration studied. For the accident conditions defined for this benchmark, the axially averaged flat distribution was found to be a non-conservative approximation even for low burn-ups (10 GWd/t) and without fission products; the reactivity effect of burn-up profile reached -14000 pcm for 50 GWd/t burn-up and composition including fission products.

The calculation of fission fractions and densities was also investigated. The analysis identified problems of source convergence when the axial burn-up profile is modelled.

Keywords: criticality, burn-up, PWR fuel, transport cask, axial burn-up profile, end effect, source convergence

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## **GLOSSARY OF TERMS AND ABBREVIATIONS**

ID:	Inner diameter
OD:	Outer diameter
σ:	Standard deviation
σ <sub>r</sub> :	Reduced standard deviation defined as $\sigma$ divided by the average value
pcm:	10-5
FP:	Fission product
BU:	Burn-up
Δρ:	Reactivity effect
Fission density:	Volume-averaged fission reaction rate in a given region (see § 4)
Fission fraction:	Proportion of fissions in a given region (see § 4)

For the two last quantities the normalisation used is such that the sum over all regions is equal to 1.

### I. INTRODUCTION

The aim of Phase II of the OECD/NEA Burn-up Credit working group was to study the effect of axial burn-up profile on the criticality of configurations containing PWR fuel assemblies. This phase was divided into two benchmark exercises, namely Phase II-A and Phase II-B. A description of these benchmarks is given below. This report presents the results and analysis of Phase II-B.

#### Phase II-A

The configuration considered was a laterally infinite array of PWR fuel with the following characteristics:

- initial enrichment equal to 3.6 wt% or 4.5 wt%;
- fuel diameter equal to 0.824 cm and array pitch equal to 1.33 cm which lead to a moderation ration Vmod/Vox = 2.0;
- different burn-ups: 0, 10, 30 or 50 GWd/t, and two cooling times: 1 or 5 years;
- axially, a symmetrical configuration was adopted comprising 9 fuel regions (total height = 365.7 cm), an upper and lower plug and water reflector (30 cm).

In total 26 configurations were calculated by 18 different participants from 10 different countries.

#### Phase II-B

A realistic configuration of 21 PWR spent fuel assemblies in a stainless steel transport flask was evaluated (see Appendix 1 and Figures 1, 2 and 3). A borated stainless steel basket centred in the flask separates the assemblies. The basket ( $5\times5$  array with the four corner positions removed) was fully flooded with water. The main characteristics of the fuel assembly are:

- 17×17 array (289 rods, no guide tubes), water moderated cells with pitch equal to 1.2598 cm;
- initial fuel enrichment equal to 4.5 wt%;
- fuel diameter equal to 0.8192 cm, rod ID = 0.8357 cm and OD = 0.9500 cm which lead to a moderation ratio Vmod / Vox = 1.67.

Nine different specified cases were studied (which are a subset of the total 26 cases studied in Phase II-A). The following parameters were considered:

- Burn-up: 0 (fresh fuel), 30 GWd/t or 50 GWd/t.
- Cooling time: 5 years.
- Fuel composition: the composition used was specified in Phase II-A (see Appendix 1). For irradiated fuels, two types of representation were studied, one where the composition included both actinides and fission products and a second where only actinides were present.
- Axial burn-up modelling: as in Phase II-A, the effect of burn-up profile modelling was studied. Two approximations were compared: one uniform burn-up zone (equal to the axial average burn-up) and an axially symmetrical distributed burn-up represented by nine uniform zones as shown in Figure 3; the burn-up in each zone is given in the following table.

	Zone dimension (in cm) and burn-up (in GWd/t)						
Zone number		1 and 9	2 and 8	3 and 7	4 and 6	5	
Dimension (cm	)	5	5	10	20	285.7	
Burn-up (GWd Av. = 30 GWd	/t) ′t	12.33	14.04	18.01	24.01	32.86	
Burn-up (GWd Av. = 50 GWd	/t) ′t	21.57	24.02	30.58	40.42	54.61	

These cases are summarised in Table 1.

D. Mennerdahl made a proposal for two additional benchmarks (X1 and X2) in order to accentuate the effect of axial burn-up profile discretisation in accident conditions (Appendix 2). The specifications of these benchmarks are close to those of Cases A and B: burn-up equal to 30 GWd/t, fission products included, with or without burn-up profile. The only change consists of reducing the borated steel basket height. Thus, while the top of this basket is at the same level as water in the basic cases (A and B), it becomes 20 cm lower than the top of fuel assemblies in the modified cases (X1 and X2). This introduces a strong axial heterogeneity to the problem which has an important impact on modelling effects associated with representations of the axial burn-up profile.

Fourteen participants from seven different countries submitted partial or complete results ( $k_{eff}$  and fission densities). Table 2 gives a brief description of the participants, of the system of codes and of cross-sections libraries used. A more detailed description is reported in Appendix 3.

#### II. SOME STATISTICAL CONSIDERATIONS

The statistical analysis presented in this report is slightly different from the one considered in Phase II-A. Some definitions are first introduced before the analysis of results.

An estimate of the average value of a sample of n data x<sub>i</sub> is given by:

$$\overline{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

When n is the full size of the sample, the standard deviation, which characterises the spread of the sample, is defined as:

$$S = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \overline{x})^2}{n}}$$

When n is not the full size of the sample, an unbiased estimate of the standard deviation is given by:

$$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \overline{x})^2}{n-1}}$$

Using these definitions, it is clear that the value of  $\sigma$  depends on the magnitude of  $x_i$ . As an example, let us consider two series of results:  $(x_1 = 0.90, x_2 = 1.00, x_3 = 1.10)$  and  $(y_1 = 9.00, y_2 = 10.00, y_3 = 11.00)$ , we find:

 $\overline{x} = 1.00$  and the corresponding  $\sigma = 0.10$ ;  $\overline{y} = 10.00$  and the corresponding  $\sigma = 1.00$ .

At first sight we might conclude that the spread in the  $y_i$  series is higher than the  $x_i$  series, which would be misleading since the two series are similarly distributed. In this case the parameter chosen to characterise the spread of the samples is not adequate for comparison purposes. It is more convenient to use the relative standard deviation defined as:

$$S_r = \frac{S}{|\overline{x}|}$$

that gives the same spread for the two series, i.e.  $S_r = 10\%$ .

In this study, the x<sub>i</sub> are parameters (k<sub>eff</sub>, reaction rates) calculated by different participants. Because of the complexity of the configuration investigated, all calculations, except those carried out by CSN, were based on the Monte Carlo method. Thus, for each x<sub>i</sub> value, as well as for the average, there is an associated statistical uncertainty. The statistical uncertainty in  $\overline{x}$  is the square root of the quadratic sum of the individual statistical uncertainties divided by n. A typical value of the statistical uncertainty on individual keff is 0.02%. Thus, the average keff values are statistically very accurate and the associated relative standard deviation reflects the real spread of results. On the other hand, statistically accurate results are more difficult to obtain for reactions rates, particularly in regions where the flux is very small. It is not unusual to find individual statistical uncertainties of the order of the x<sub>i</sub> value. Thus, the value  $\overline{x}$ has statistical uncertainty strongly contributes average а large that to the relative standard deviation.

#### III. RESULTS AND DISCUSSION

#### 1. Multiplication factors and standard deviation

Table 3 lists the multiplication factors obtained by all participants. It also provides the average multiplication factor and the value of the quantity  $2 * \sigma_r$ .

Table 4 shows the discrepancies in the calculated  $k_{eff}$  of each participant from the average value. These discrepancies, expressed in pcm (1 pcm = 10<sup>-5</sup>), were calculated as:

$$\ln\!\left(\frac{k_i}{\bar{k}}\right)$$

 $k_i$  is the individual multiplication factor and  $\overline{k}$  is the average k<sub>eff</sub>.

This table also shows the minimum and maximum values of the discrepancies for each case. We notice that BfS-IKE results are the lowest ones for cases with flat burn-up distribution and that CSN results are the highest ones for cases including fission products. This last observation can be explained by the absence of three FPs ( $^{95}Mo$ ,  $^{99}Tc$  and  $^{101}Ru$ ) in the CSN calculations (see CSN comments in Appendix 3). If BfS-IKE results for uniform burn-up cases (A, A', C and C') and CSN results for cases including FPs (A, B, C and D) are not taken into account in the analysis, the dispersions of k<sub>eff</sub> values are found to be smaller (sometimes by a factor of 4) for all cases (see Table 3). The results can be grouped into three main categories:

- participants with results significantly greater than the average: ABB, BNFL, IPSN, JINS-1 and UKDOT;
- participants with results significantly lower than the average: EMS, GRS, JINS-2, ORNL and PNC; all these participants use codes and cross-section libraries derived from the SCALE system;
- participants with results close to the average values: CEA and JAERI.

From Table 3 we can make the following remarks:

- the relative standard deviation is higher for fresh fuel (2σ<sub>r</sub> = 1.3%) than for cases with other major and minor actinides (from 0.5% to 1.1%);
- when fission products are included, the relative standard deviation of the calculated k<sub>eff</sub> values is decreased;
- when the axial burn-up profile is modelled, the relative standard deviation of the calculated k<sub>eff</sub> values is increased.

The lowest  $2\sigma_r$  value was obtained for 50 GWd/t burn-up, a flat burn-up profile and with composition including fission products. The first two remarks suggest the existence of compensating effects between, on the one hand, the differences of uranium cross-sections and on the other hand, the differences of other actinides and fission products cross-sections. The third remark suggests that a precise description of axial burn-up profile introduces a difficulty of computation.

The multiplication factors are rather different from those obtained in the previous benchmark exercise (Phase II-A). The differences may be attributed to:

- differences in the configurations: in Phase II-A, laterally infinite array was studied while in Phase II-B a radially finite cask containing 21 assemblies separated by borated stainless steel and reflected by stainless steel was considered; also, axial differences exist between the two configurations;
- differences in the moderation ratio.

Case # in Phase II-A	14	23	24	25	26
Case # in Phase II-B	Е	D	С	D'	C'
Burn-up (GWd/t)	0 (fresh fuel)	50	50	50	50
FP included ?		Y	Y	Ν	Ν
BU profile ?		Y	Ν	Y	Ν
(Phase II-A)					
Average k <sub>eff</sub>	1.4783	1.0543	1.0123	1.1800	1.1734
2 * o <sub>r</sub>	1.6%	1.5%	1.3%	0.9%	0.8%
(Phase II-B)					
Average k <sub>eff</sub>	1.1257	0.7933	0.7641	0.8791	0.8737
2 * <b>o</b> r	1.3%	0.8%	0.5%	1.0%	0.7%

For instance, the following table gives some comparisons:

Since the participation in the benchmarks has changed between the two phases it is not completely valid to compare the dispersion of results. Also, this dispersions depends, as shown in Table 3, on the data discarded from the analysis due to specific approximations used.

#### 2. Effect of axial burn-up distribution

In Table 5, the reactivity effect of the axial burn-up distribution (also called the end effect) is measured (in pcm) using the following expression:

$$\Delta \rho = \ln \left( \frac{k(\text{uniform axial burnup})}{k(\text{nine axial burnup zones})} \right)$$

When this value is negative, it means that a precise modelisation of the axial profile makes the multiplication factor higher and that the uniform axial burn-up hypothesis is not conservative. Table 5 also gives, for each case, the average effect of the axial burn-up and a measure of the spread of the results  $(2 * \sigma_r)$ . It is important to note that due to statistical uncertainties in  $k_{eff}$  the dispersion of the small end effects is consequently high.

From this table one can make the following remarks:

- the end effects found by BfS-IKE are very different from the other participants (this was not observed in the previous phase); indeed, as we have already noticed, BfS-IKE results for cases with flat burn-up distribution are too low, which leads to negative end effects for all cases;
- if BfS-IKE results are not considered, very good agreements are obtained between the remaining participants with a relative small spread of results (appended to Table 5 are the averages and dispersions without BfS-IKE results);
- for cases without fission products, the absolute value of the end effect is less than 1000 pcm even for 50 GWd/t burn-up;
- for the 30 GWd/t burn-up, the absolute value of the end effect is still lower than 1000 pcm, even with fission products;
- for high burn-ups the uniform distribution hypothesis is not conservative;
- the end effect increases when the fission products are included, which leads the uniform distribution to under-predict the k<sub>eff</sub> by about -4000 pcm for burn-up equal to 50 GWd/t.

All these remarks are consistent with those found in the previous benchmark exercise. The following table gives a direct comparison of the end effect in both phases (BfS-IKE results of Phase II-B were not taken into account). The end effects reported in Phase II-A were normalised by the corresponding  $k_{eff}$  values in order compare similar quantities.

Burn-up (GWd/t)	50	50
FP included ?	Y	Ν
(Phase II-A) Average end effect (pcm) $2 * \sigma_r$	-3994 22%	-559 116%
(Phase II-B) Average end effect (pcm) $2 * \sigma_r$	-3722 12%	-567 83%

A good agreement is found between the results of the two phases.

#### 3. Additional cases

The calculation results submitted by the participants to this extra exercise are reported in Table 6. As expected, these results clearly indicate that the end effect depends on the configuration studied. While the flat burn-up distribution approximation can be acceptable for configurations studied in Phase II-A and in basic Phase II-B cases, for burn-ups lower than or equal to 30 GWd/t, the additional cases show large (and thus non acceptable) under-predictions (about -8000 pcm) due to this approximation. Additional cases, calculated by D. Mennerdahl and G. Poullot show that even for a 10 GWd/t burn-up, one year cooling time and without considering FPs, the flat distribution

approximation under-predicts the  $k_{eff}$  by about -2000 pcm and that this under-prediction exceeds -14000 pcm for a 50 GWd/t burn-up when FPs are included. Clearly, axially homogeneous fuel burn-up models are not suitable for cases where other strong axial heterogeneities are present.

#### 4. Fission fractions and densities

The end effect discussed in the previous section is related to axial fission distribution. In Phase II-A, fission densities in nine zones, as defined in the following formula, were investigated:

$$X_{i} = \frac{\frac{\int_{V_{i}} \Sigma_{f}(\vec{r}, E) \Phi(\vec{r}, E) d\vec{r} dE}{V_{i}}}{\sum_{i} \left( \frac{\int_{V_{i}} \Sigma_{f}(\vec{r}, E) \Phi(\vec{r}, E) d\vec{r} dE}{V_{i}} \right)}$$
(1)

where  $V_i$  is the volume of zone i,  $\Phi$  is the scalar flux and  $\Sigma_f$  the fission macroscopic cross-section.  $X_i$  is then the number of fissions by unit volume in region i normalised to one fission by unit volume in the whole system. In Phase II-B, contributors were asked to calculate fission fractions, defined as:

$$F_{i} = \frac{\int_{V_{i}} \Sigma_{f}(\vec{r}, E) \Phi(\vec{r}, E) d\vec{r} dE}{\sum_{i} \int_{V_{i}} \Sigma_{f}(\vec{r}, E) \Phi(\vec{r}, E) d\vec{r} dE}$$
(2)

 $F_i$  is then the number of fissions in region i normalised to one fission in the whole system. The data submitted by participants are collected in Table 7. One can easily see that different definitions and normalisation assumptions were used. The data submitted by BNFL was a five-zone fission profile were regions 1+9, 2+8, 3+7and 4+6 were summed, which assumes that the fission profile may be treated being symmetric. Since the asymmetry of fission distribution will as be investigated, BNFL data was not considered in this section. The data in Table 7 was first normalised to unity by dividing each value by the sum over all regions (Table 8). From this table we clearly see that BfS-IKE, BNFL, CSN, EMS, JAERI, ORNL and UKDOT calculated fission densities while IPSN, JINS-1, JINS-2 and PNC calculated fission fractions. Table 9 gives the modified results of all participants in terms of fission fractions and Table 10 gives fission densities. To transform fission fractions into fission densities each value  $F_i$  is divided by the volume of the corresponding zone and the resulting values are normalised to unity. Multiplying  $X_i$  values by the corresponding volume and normalising the resulting values to unity is required to transform fission densities to fission fractions. In Tables 9 and 10, average values and dispersions among participants are also reported. Here again, it is important to note that due to Monte Carlo statistical uncertainties, regions where reaction rates are small are not adequately sampled. The dispersion of these results is strongly influenced by statistical uncertainties.

Fission fractions and densities (average values in Tables 9 and 10) for flat burn-up cases (A, C and E) and for distributed burn-up cases (B and D) are presented in Figures 4, 4bis, 5 and 5bis.

While about 90% of fissions occur in the central region for flat burn-up cases, this proportion decreases with increasing burn-up for distributed burn-up cases: about 50% for 30 GWd/t and 28% for 50 GWd/t. Fission in peripheral regions shows corresponding increases which helps explain changes in the end effect with burn-up. This effect is perhaps shown more clearly in the fission densities (Figures 4bis and 5bis). For flat axial burn-up cases, the fission density is close to a cosine while in distributed axial burn-up cases the fission density is minimal in the central region. This phenomenon is accentuated with increasing burn-up. Note that for cases with burn-up profile it is unclear whether the fission distribution is symmetrical or not. In fact, the configuration is slightly asymmetrical due to additional hardware at the top of the cask. So, despite the symmetrical burn-up profile, the resulting fission density may show strong asymmetry. For instance, at a first sight, Case D (50 GWd/t with fission products) seems to present a symmetrical profile (Figure 5 or 5bis), but this results from compensations since there are three classes of results of equal importance:

- strongly asymmetrical distribution toward the top of the cask;
- strongly asymmetrical distribution toward the bottom of the cask;
- symmetrical distribution.

A more accurate representation of fission or flux distribution was investigated by J. Conde and J. Stewart. Figure 6 gives fission density distribution obtained by Stewart for Cases D, D' and E and Figures 7 and 8 give neutron fluxes calculated by Conde for Cases A through E.

Figures 9 through 13 (respectively 9bis through 13bis) give the fission fractions (respectively fission densities) obtained by participants for Cases A, B, C, D and E. It is not surprising that the agreement between participants are fairly good for cases with flat burn-up distribution. In contrast, Cases B and D where a burn-up profile was modelled exhibit large discrepancies. The shapes obtained for fission fractions do not show the same asymmetry properties. For some participants, strong asymmetry is observed, favouring regions at the top of the fuel assembly (BfS-IKE, IPSN, JAERI) or at the bottom (CSN, ORNL and UKDOT), while some fission profiles are quite symmetrical (JINS-1, JINS-2, PNC). The fission profile is related to the eigenfunction convergence in the calculation which was not achieved in the same way in different codes. The discussion of this phenomenon cannot be carried out in detail in this report since it requires more information about calculation parameters (number of neutrons per generation, neutron source distribution in the first generation...) and the achieve convergence strategy of each code to control and to the (number of generation skipped and source powering algorithms). Some participants consider that this is a secondary problem since only eigenvalue convergence is required and others believe that eigenfunction convergence is also of importance. Some tests were made by S. Mitake and O. Sato in order to study the effect of calculation parameters on the convergence (see Appendix 5). In particular, the number of generations was varied from 103 to 3203 with fixed number of neutrons by generation equal to 300. The results show that the convergence is not achieved even with increased generations and that the deviation of multiplication factors are about 0.5% Ak/k. The effect of the number of neutrons by generation (with fixed number of generations) was also investigated and the results show that eigenfunction convergence was achieved with about 2400 neutrons by generation. Other tests were made by G. Poullot and A. Nouri on the effect of initial source distribution on the convergence. The results clearly show that this distribution is of importance for cases with burn-up profile and that its effect on the eigenvalue may be important.

In conclusion, this section showed that the eigenfunction convergence aspects (calculation parameters and powering strategy) become important for configurations with distributed burn-up profile. More detailed discussions require specific calculations and code comparisons and it may be of interest to be investigated in a separate phase.

#### 5. Safety margins

As far as the end effect is concerned, the results of this phase can be summarised by considering the safety margins available in different calculation hypotheses. To this end, the reference calculation is taken for irradiated fuel where the composition includes actinides and the fifteen selected fission products and with axial burn-up described by nine uniform zones. The progressive hypotheses that were considered in this study are:

- 1) fresh fuel;
- 2) irradiated fuel where the composition includes only actinides (without FPs) and axially average flat burn-up distribution;
- 3) irradiated fuel including actinides and FPs and with axially average flat burn-up distribution.

The safety margins are then evaluated as:

$$\Delta \rho = \ln \left( \frac{k_{eff} \text{ (hypothesis)}}{k_{eff} \text{ (reference)}} \right) \text{ (in pcm)}$$

The following tables give these margins for the two kinds of configurations studied, namely: basic cases and accidental situations (in accidental situations, additional results for burn-up equal to 50 GWd/t were submitted by D. Mennerdhal and G. Poullot). We see that average flat burn-up approximation should be used with care since it can lead to non-conservative results, even for irradiated fuel composition without FPs. The reactivity effect resulting from axial burn-up approximations should be evaluated for each practical application.

	Modelling approximations				
Burn-up	(GWd/t)	Fresh fuel	Irradiated fuel No FPs – Flat burn-up	Irradiated fuel FPs included – Flat b	ourn-up
3	0	22820	8010	-350	
5	0	34870	9370	-3990	

#### Safety margins for basic cases (in pcm)

#### Safety margins for accidental situations (in pcm)

Modelling approximations					
Burn-up	(GWd/t)	Fresh fuel	Irradiated fuel No FPs – Flat burn-up	Irradiated fuel FPs included – Flat burn-up	
3	0	14530	700	-8120	
5	0	23870	10	-14480	

#### **IV. CONCLUSIONS**

In the Phase II-B benchmark, a realistic configuration describing 21 PWR spent fuel assemblies in a stainless steel transport cask was studied to analyse the effect of the axial burn-up distribution on the multiplication factor. Additional cases addressing an accidental upward shift of the fuel assemblies were also studied. If we restrict ourselves to the basic cases (A through E and A' through D'), the conclusions of this study can be presented as follows:

- If one discards CSN results for cases which include FPs and BfS-IKE results for cases with flat burn-up distribution, good agreements were found between the results submitted by the twelve other participants. The difference of individual results from the average multiplication factor varies from -700 pcm to +700 pcm, except for fresh fuel where the discrepancies vary from -1000 pcm to +1000 pcm.
- The end effect is small for burn-ups less than or equal to 30 GWd/t or for cases without fission products (less than 1000 pcm).
- When the burn-up exceeds 30 GWd/t and when fission products are included in the fuel composition, the end effect becomes important and the uniform axial distribution underpredicts the multiplication factor by about -4000 pcm.

These results are fairly consistent with those obtained in the Phase II-A.

However, results for the accident configurations illustrate the limitations of the last two conclusions. The axially average flat burn-up distribution is found to be a non-conservative approximation, even for very low burn-ups and without including FPs. Clearly, the use of axially homogeneous fuel compositions may be unsuitable for cases where there are significant axial heterogeneities.

The comparison of fission distributions indicates problems of eigenfunction convergence for cases with burn-up profile. This problem involves code algorithms and calculation parameters that are not all known for this study. Complementary studies are needed to investigate this particular problem of convergence in more detail.

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Case #	Burn-up (GWd/t)	Axial profile modelled?	Fission product included?
А	30	No	Yes
A'	30	No	No
В	30	Yes	Yes
B'	30	Yes	No
С	50	No	Yes
C'	50	No	No
D	50	Yes	Yes
D'	50	Yes	No
E	0 (fresh fuel)	_	_

## Table 1. Cases identification (nine basic cases)

For all irradiated fuels the cooling time is equal to five years.

## Table 2. List of participants

#	Participan t	Country	Code used	Library used	Groups	Comments
1	ABB	Sweden	PHOENIX4 (2-D lattice code) + KENO-V.a (MC)	PHOENIX4 library (ENDF/B6)	89	MC calculation performed using 99 groups
2	BfS-IKE	Germany	CHM / MORSE-K	242-group library (JEF-1) 60-group for MORSE	242/60	Cr and Fe were omitted in the fuel cladding material
3	BNFL	UK	MONK (MC)	8220 group UKNDL + JEF2.2 for FP	Pointwise	
4	CEA	France	APOLLO-2 (assembly code) + TRIMARAN-2 (MC)	CEA93 (JEF2.2)	99	MC calculation performed using 16 groups
5	CSN	Spain	CASMO-3/SIMULATE-3P	70-group E4LTJB7 (ENDF/B4-B5 anf JEF2)	70	<sup>95</sup> Mo, <sup>99</sup> Tc and <sup>101</sup> Ru were omitted
6	EMS	Sweden	SCALE-4.1	27 group burn-up library	27	
7	GRS	Germany	SCALE-4	27 group depletion library	27	
8	IPSN	France	APOLLO-1 (assembly code) + MORET-3 (MC)	CEA86 (JEF1 + ENDF/B4 and B5)	99	
9	JAERI	Japan	MCNP-4A (MC)	JENDL3.2	Pointwise	
10	JINS-1	Japan	KENO-V.a (MC)	MGCL-JINS (JENDL3.2 for FP and ENDF/B4 for the others)	137	Fuel pellets, clads and moderators are modelled individually. No smeared technique applied.
11	JINS-2	Japan	KENO-V.a (MC)	Scale 27 group library	27	
12	ORNL	USA	SCALE-4.3	Scale 44Groupndf5	44	CSAS25 sequence for no axial distribution. CSASN sequence + stand-alone KENO-V.a for cases with axial distribution.
13	PNC	Japan	SCALE-4.2	27 group burn-up library	27	
14	UKDOT	UK	MONK-6.B (MC)	8220 group UKNDL + JEF2.2 for FP	Pointwise	

			Case #	А	Α'	В	Β'	С	C'	D	D'	E
			Burn-up (GWd/t)	30	30	30	30	50	50	50	50	0 (fresh fuel)
			Fission product included?	Y	Ν	Y	Ν	Y	Ν	Y	Ν	_
			Burn-up profile modelled?	Ν	Ν	Y	Y	Ν	N	Y	Y	_
#	Institute	Country	Code used	А	Α'	В	Β'	С	C'	D	D'	Е
1	ABB	Sweden	PHOENIX4/KENO-V.a	0.8953		0.8968		0.7665		0.7950		1.1309
2	BfS-IKE	Germany	CGM/MORSE-K	0.8762	0.9595	0.9003	0.9693	0.7407	0.8553	0.7977	0.8839	1.1272
3	BNFL	UK	MONK	0.8958	0.9780	0.9008	0.9689	0.7640	0.8765	0.7967	0.8811	1.1345
4	CSN	Spain	CASMO-3/SIMULATE-3P	0.9034	0.9742	0.9058	0.9676	0.7755	0.8753	0.8073	0.8847	1.1246
5	CEA	France	APOLLO-2 + TRIMARAN-2	0.8932	0.9714	0.8916	0.9636	0.7613	0.8749	0.7906	0.8791	1.1297
6	EMS	Sweden	SCALE-4.1	0.8900	0.9683	0.8900	0.9594	0.7630	0.8720	0.7923	0.8751	1.1155
7	GRS	Germany	SCALE-4	0.8917	0.9652	0.8906	0.9588	0.7625	0.8706	0.7915	0.8754	1.1172
8	IPSN	France	APOLLO-1 + MORET-3	0.8976	0.9776	0.8978	0.9709	0.7651	0.8770	0.7944	0.8846	1.1337
9	JAERI	Japan	MCNP-4A	0.8923	0.9718	0.8919	0.9629	0.7650	0.8733	0.7923	0.8771	1.1291
10	JINS-1	Japan	KENO-V.a	0.8997	0.9773	0.8997	0.9711	0.7690	0.8792	0.7988	0.8831	1.1270
11	JINS-2	Japan	KENO-V.a	0.8883	0.9641	0.8908	0.9573	0.7614	0.8683	0.7885	0.8742	1.1122
12	ORNL	USA	SCALE-4.3	0.8912	0.9684	0.8944	0.9594	0.7642	0.8711	0.7921	0.8721	1.1214
13	PNC	Japan	SCALE-4.2	0.8904	0.9670	0.8913	0.9602	0.7628	0.8703	0.7890	0.8756	1.1202
14	UKDOT	UK	MONK-6.B	0.8956	0.9763	0.9028	0.9716	0.7644	0.8757	0.7940	0.8817	1.1363
			Case #	А	A'	В	Β'	С	C'	D	D'	Е
			Average k <sub>eff</sub>	0.8929	0.9707	0.8960	0.9647	0.7632	0.8723	0.7943	0.8791	1.1257
			$2 \sigma_r$	1.4%	1.2%	1.1%	1.1%	1.9%	1.3%	1.2%	1.0%	1.3%
			Average*	0.8934	0.9716	0.8953	0.9647	0.7641	0.8737	0.7933	0.8791	1.1257
			$2 \sigma_{r}^{*}$	0.7%	1.0%	1.0%	1.1%	0.5%	0.7%	0.8%	1.0%	1.3%

Table 3. Multiplication factors  $k_{eff}$  from participants (nine basic cases)

\* Average value and relative standard deviation were calculated without taking into account BfS-IKE results for cases A, A' C and C' and CSN results for cases A, B, C and D.

Table 4. Relative difference from average  $k_{\mbox{\tiny eff}}$  value (nine basic cases)

$\ln\!\left(\frac{k_{eff,i}}{\bar{k}_{eff}}\right)$	expressed in pcm
-----------------------------------------------------	------------------

Case #	А	A'	В	Β'	С	C'	D	D'	Е
Burn-up (GWd/t)	30	30	30	30	50	50	50	50	0 (fresh fuel)
Fission product included?	Y	Ν	Y	Ν	Y	Ν	Y	Ν	_
Burn-up profile modelled?	Ν	Ν	Y	Y	Ν	Ν	Y	Y	_

#	Institute	Country	Code used	А	A'	В	Β'	С	C'	D	D'	Е
1	ABB	Sweden	PHOENIX4/KENO-V.a	268		84		426		88		463
2	BfS-IKE	Germany	CGM/MORSE-K	-1889	-1161	474	476	-2998	-1965	427	550	135
3	BNFL	UK	MONK	324	749	529	435	99	484	301	232	781
4	CSN	Spain	CASMO-3/SIMULATE-3P	1168	359	1083	300	1593	347	1624	640	-98
5	CEA	France	APOLLO-2 + TRIMARAN-2	33	71	-497	-114	-255	301	-467	5	357
6	EMS	Sweden	SCALE-4.1	-326	-248	-677	-551	-32	-31	-252	-451	-908
7	GRS	Germany	SCALE-4	-135	-569	-610	-613	-97	-192	-353	-417	-756
8	IPSN	France	APOLLO-1 + MORET-3	524	708	196	641	243	541	12	629	710
9	JAERI	Japan	MCNP-4A	-71	116	-461	-183	234	117	-254	-222	306
10	JINS-1	Japan	KENO-V.a	761	681	407	665	754	796	566	459	116
11	JINS-2	Japan	KENO-V.a	-519	-682	-586	-769	-247	-460	-729	-553	-1204
12	ORNL	USA	SCALE-4.3	-191	-238	-184	-551	125	-134	-278	-794	-381
13	PNC	Japan	SCALE-4.2	-281	-383	-531	-467	-58	-226	-670	-394	-488
14	UKDOT	UK	MONK-6.B	301	575	751	713	151	393	-38	300	939
			Minimum relative difference	-1889	-1161	-677	-769	-2998	-1965	-729	-794	-1204
			Maximum relative difference	1168	749	1083	713	1593	796	1624	640	939

## Table 5. Reactivity effect of burn-up profile (basic cases)

$\Lambda q = \ln \left( \frac{1}{2} \right)$	$k_{eff}(uniform axial burn - up)$	overaged in norm
$\Delta p = m($	$\overline{\mathbf{k}_{eff}}$ (nine axial burn - up zones)	expressed in peni

Case #	1	2	3	4
Burn-up (GWd/t)	30	30	50	50
Fission product included?	Y	Ν	Y	Ν

#	Institute	Country	Code used	1	2	3	4
1	ABB	Sweden	PHOENIX4/KENO-V.a	-167		-3651	
2	BfS-IKE	Germany	CGM/MORSE-K	-2713	-1016	-7414	-3289
3	BNFL	UK	MONK	-557	935	-4191	-523
4	CSN	Spain	CASMO-3/SIMULATE-3P	-265	680	-4020	-1068
5	CEA	France	APOLLO-2 + TRIMARAN-2	179	806	-3776	-479
6	EMS	Sweden	SCALE-4.1	0	923	-3768	-355
7	GRS	Germany	SCALE-4	123	665	-3733	-550
8	IPSN	France	APOLLO-1 + MORET-3	-22	688	-3758	-863
9	JAERI	Japan	MCNP-4A	39	919	-3501	-436
10	JINS-1	Japan	KENO-V.a	3	636	-3801	-438
11	JINS-2	Japan	KENO-V.a	-284	708	-3506	-682
12	ORNL	USA	SCALE-4.3	-358	934	-3586	-115
13	PNC	Japan	SCALE-4.2	-101	706	-3377	-607
14	UKDOT	UK	MONK-6.B	-801	483	-3799	-683
			Average	-352	620	-4006	-776
			2* o <sub>r</sub>	401%	158%	50%	196%
			Average (without BfS-IKE)	-170	757	-3722	-567
			$2 * \sigma_r$ (without BfS-IKE)	317%	37%	12%	83%

A negative value of  $\Delta\rho$  means that the uniform axial burn-up hypothesis is not conservative.

Table 6. k<sub>eff</sub> and reactivity effect of burn-up profile for additional benchmarks (accidental situations cf. Appendix 4)

Δρ()	pcm) = ln $\left(\frac{k_{eff} \text{ (without profile)}}{k_{eff} \text{ (with profile)}}\right)$	$\left(\frac{e}{2}\right)$	
	Case #	X1	X2
	Burn-up (GWd/t)	30	30
	Fission product included?	Y	Y

			Burn-up profile modelled?	Ν	Y	
#	Institute	Country	Code used	$\mathbf{k}_{\text{eff}}$	$\mathbf{k}_{\mathrm{eff}}$	End effect $\Delta \rho$ (pcm)
3	BNFL	UK	MONK	0.9236	1.0003	-7978
5	CEA	France	APOLLO-2 + TRIMARAN-2	0.9216	1.0026	-8424
6	EMS	Sweden	SCALE-4.1	0.9291	1.0035	-7703
8	IPSN	France	APOLLO-1 + MORET-3	0.9295	1.0081	-8118
10	JINS-1	Japan	KENO-V.a	0.9328	1.0094	-7892
11	JINS-2	Japan	KENO-V.a	0.9222	0.9998	-8079
14	UKDOT	UK	MONK-6.B	0.9219	1.0003	-8162

Average

2\* σ<sub>r</sub>

0.9258

0.9%

1.0034

0.7%

-8051

5.2%

			CA	ASE A	Burn-ı	up = 30	GWd/t - 1	FP inclue	ded – No	BU prot	file	CAS	SE A'	Burn-up	0 = 30  GV	Wd/t – N	o FP inc	luded – I	No BU pi	rofile
#	Institute	Country	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9
1	ABB	Sweden	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
2	BfS-IKE	Germany	6.52	7.944	11.2	16.52	27.36	12.41	8.767	5.179	4.102	1.835	3.946	3.83	6.924	39.09	19.46	11.1	7.707	6.107
3	BNFL	UK	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
4	CSN	Spain	0.135	0.19	0.282	0.462	1.184	0.466	0.286	0.194	0.142	0.134	0.189	0.281	0.462	1.184	0.466	0.3	0.194	0.141
5	CEA	France	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
6	EMS	Sweden	0.05	0.06	0.09	0.14	0.28	0.15	0.11	0.08	0.06	0.05	0.06	0.09	0.15	0.27	0.15	0.1	0.07	0.05
7	GRS	Germany	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
8	IPSN	France	6E-04	8E-04	0.002	0.009	0.932	0.039	0.011	0.003	0.002	0.001	0.002	0.005	0.024	0.942	0.017	0.006	0.002	0.001
9	JAERI	Japan	0.041	0.06	0.084	0.124	0.361	0.138	0.085	0.062	0.045	0.037	0.051	0.079	0.136	0.483	0.099	0.057	0.034	0.023
10	JINS-1	Japan	0.002	0.003	0.007	0.022	0.898	0.045	0.014	0.005	0.004	0.002	0.003	0.01	0.033	0.912	0.027	0.008	0.003	0.002
11	JINS-2	Japan	0.002	0.003	0.01	0.03	0.918	0.024	0.007	0.003	0.002	0.002	0.003	0.008	0.027	0.92	0.026	0.008	0.003	0.002
12	ORNL	USA	2E-07	2E-07	3E-07	5E-07	9E-07	2E-07	1E-07	1E-07	8E-08	2E-07	2E-07	3E-07	5E-07	1E-06	3E-07	2E-07	1E-07	7E-08
13	PNC	Japan	0.003	0.004	0.011	0.034	0.906	0.029	0.009	0.003	0.002	0.002	0.003	0.009	0.027	0.909	0.034	0.01	0.003	0.002
14	UKDOT	UK	0.012	0.015	0.023	0.038	0.34	0.243	0.149	0.099	0.081	0.048	0.062	0.091	0.15	0.365	0.124	0.076	0.049	0.035
			CAS	SE B	Burn-up	0 = 30  GV	Wd/t – Fl	P include	ed – Nine	-zone pr	ofile	CASE	E <b>B'</b> I	Burn-up =	= 30 GW	d/t – No	FP inclu	ded – Ni	ne-zone	profile
#	Institute	Country	CAS Reg-1	SE B Reg-2	Burn-up Reg-3	= 30 GV Reg-4	Wd/t – Fl Reg-5	P include Reg-6	d – Nine Reg-7	-zone pr Reg-8	ofile Reg-9	CASE Reg-1	E <b>B'</b> H Reg-2	Burn-up = Reg-3	= 30 GW Reg-4	d/t – No Reg-5	FP inclu Reg-6	ded – Ni Reg-7	ne-zone Reg-8	profile Reg-9
# 1	Institute ABB	Country Sweden	CAS Reg-1	<b>SE B</b> Reg-2	Burn-up Reg-3	= 30 GV Reg-4 /	Wd/t – Fl Reg-5 /	P include Reg-6 /	ed – Nine Reg-7 /	e-zone pr Reg-8 /	ofile Reg-9 /	CASH Reg-1 /	E <b>B'</b> H Reg-2	Burn-up = Reg-3 /	= 30 GW Reg-4 /	d/t – No Reg-5 /	FP inclu Reg-6	ded – Ni Reg-7 /	ne-zone Reg-8 /	profile Reg-9 /
# 1 2	Institute ABB BfS-IKE	Country Sweden Germany	CAS Reg-1 / 0.751	<b>SE B</b> Reg-2 / 0.862	Burn-up Reg-3 / 1.104	e = 30 GV Reg-4 / 1.233	Wd/t - Fl Reg-5 / 3.969	P include Reg-6 / 26.22	ed – Nine Reg-7 / 26.46	-zone pr Reg-8 / 21.75	ofile Reg-9 / 17.65	CASE Reg-1 / 7.403	E <b>B'</b> F Reg-2 / 9.055	3urn-up = Reg-3 / 12.22	= 30 GW Reg-4 / 14.93	d/t – No Reg-5 / 11.46	FP inclu Reg-6 / 15.22	ded – Ni Reg-7 / 12.46	ne-zone Reg-8 / 9.676	profile Reg-9 / 7.58
# 1 2 3	Institute ABB BfS-IKE BNFL	Country Sweden Germany UK	CAS Reg-1 / 0.751 0.086	SE B Reg-2 / 0.862 0.111	Burn-up Reg-3 / 1.104 0.135	e = 30 GV Reg-4 / 1.233 0.135	Vd/t - Fl Reg-5 / 3.969 0.066	P include Reg-6 / 26.22 0.135	ed – Nine Reg-7 / 26.46 0.135	-zone pr Reg-8 / 21.75 0.111	ofile Reg-9 / 17.65 0.086	CASH Reg-1 / 7.403 0.074	E <b>B'</b> F Reg-2 / 9.055 0.095	Burn-up = Reg-3 / 12.22 0.12	= 30 GW Reg-4 / 14.93 0.138	d/t – No Reg-5 / 11.46 0.146	FP inclu Reg-6 / 15.22 0.138	ded – Ni Reg-7 / 12.46 0.12	ne-zone Reg-8 / 9.676 0.095	profile Reg-9 / 7.58 0.074
# 1 2 3 4	Institute ABB BfS-IKE BNFL CSN	Country Sweden Germany UK Spain	CAS Reg-1 / 0.751 0.086 0.118	<b>SE B</b> Reg-2 / 0.862 0.111 0.153	Burn-up Reg-3 / 1.104 0.135 0.186	e = 30 GV Reg-4 / 1.233 0.135 0.183	Wd/t – Fl Reg-5 / 3.969 0.066 0.597	P include Reg-6 / 26.22 0.135 4.943	rd – Nine Reg-7 / 26.46 0.135 5.105	-zone pr Reg-8 / 21.75 0.111 4.249	ofile Reg-9 / 17.65 0.086 3.365	CASH Reg-1 / 7.403 0.074 0.679	E B' F Reg-2 / 9.055 0.095 0.901	Burn-up = Reg-3 / 12.22 0.12 1.149	= 30 GW Reg-4 / 14.93 0.138 1.279	d/t - No Reg-5 / 11.46 0.146 0.847	FP inclu Reg-6 / 15.22 0.138 2.216	ded – Ni Reg-7 / 12.46 0.12 2.015	ne-zone Reg-8 / 9.676 0.095 1.596	profile Reg-9 / 7.58 0.074 1.236
	Institute ABB BfS-IKE BNFL CSN CEA	Country Sweden Germany UK Spain France	CA: Reg-1 / 0.751 0.086 0.118 /	SE B Reg-2 / 0.862 0.111 0.153 /	Burn-up Reg-3 / 1.104 0.135 0.186 /	e = 30 GV Reg-4 / 1.233 0.135 0.183 /	Wd/t – Fl Reg-5 / 3.969 0.066 0.597 /	P include Reg-6 / 26.22 0.135 4.943 /	rd – Nine Reg-7 / 26.46 0.135 5.105 /	e-zone pr Reg-8 / 21.75 0.111 4.249 /	ofile Reg-9 / 17.65 0.086 3.365 /	CASI Reg-1 / 7.403 0.074 0.679 /	E <b>B'</b> E Reg-2 / 9.055 0.095 0.901 /	Burn-up = Reg-3 / 12.22 0.12 1.149 /	= 30 GW Reg-4 / 14.93 0.138 1.279 /	d/t - No Reg-5 / 11.46 0.146 0.847 /	FP inclu Reg-6 / 15.22 0.138 2.216 /	ded – Ni Reg-7 / 12.46 0.12 2.015 /	ne-zone Reg-8 / 9.676 0.095 1.596 /	profile Reg-9 / 7.58 0.074 1.236 /
$ $	Institute ABB BfS-IKE BNFL CSN CEA EMS	Country Sweden Germany UK Spain France Sweden	CAS Reg-1 / 0.751 0.086 0.118 / 0.02	SE B Reg-2 / 0.862 0.111 0.153 / 0.02	Burn-up Reg-3 / 1.104 0.135 0.186 / 0.03	e = 30 GV Reg-4 / 1.233 0.135 0.135 0.183 / 0.03	Wd/t - Fl Reg-5 / 3.969 0.066 0.597 / 0.03	P include Reg-6 / 26.22 0.135 4.943 / 0.25	ed – Nine Reg-7 / 26.46 0.135 5.105 / 0.25	-zone pr Reg-8 / 21.75 0.111 4.249 / 0.2	ofile Reg-9 / 17.65 0.086 3.365 / 0.17	CASI Reg-1 / 7.403 0.074 0.679 / 0.13	E <b>B'</b> F Reg-2 / 9.055 0.095 0.901 / 0.16	Burn-up = Reg-3 / 12.22 0.12 1.149 / 0.21	= 30 GW Reg-4 / 14.93 0.138 1.279 / 0.24	d/t - No Reg-5 / 11.46 0.146 0.847 / 0.08	FP inclu Reg-6 / 15.22 0.138 2.216 / 0.06	ded – Ni Reg-7 / 12.46 0.12 2.015 / 0.05	ne-zone Reg-8 / 9.676 0.095 1.596 / 0.04	profile Reg-9 / 7.58 0.074 1.236 / 0.03
	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS	Country Sweden Germany UK Spain France Sweden Germany	CAS Reg-1 / 0.751 0.086 0.118 / 0.02 /	SE B Reg-2 / 0.862 0.111 0.153 / 0.02 /	Burn-up Reg-3 / 1.104 0.135 0.186 / 0.03 /	e = 30 GV Reg-4 / 1.233 0.135 0.135 0.183 / 0.03 /	Wd/t - Fl Reg-5 / 3.969 0.066 0.597 / 0.03 /	P include Reg-6 / 26.22 0.135 4.943 / 0.25 /	rd – Nine Reg-7 / 26.46 0.135 5.105 / 0.25 /	-zone pr Reg-8 / 21.75 0.111 4.249 / 0.2 /	ofile Reg-9 / 17.65 0.086 3.365 / 0.17 /	CASI Reg-1 / 7.403 0.074 0.679 / 0.13 /	E B' F Reg-2 / 9.055 0.095 0.901 / 0.16 /	Burn-up = Reg-3 / 12.22 0.12 1.149 / 0.21 /	= 30 GW Reg-4 / 14.93 0.138 1.279 / 0.24 /	d/t - No Reg-5 / 11.46 0.146 0.847 / 0.08 /	FP inclu Reg-6 / 15.22 0.138 2.216 / 0.06 /	ded – Ni Reg-7 / 12.46 0.12 2.015 / 0.05 /	ne-zone Reg-8 / 9.676 0.095 1.596 / 0.04 /	profile Reg-9 / 7.58 0.074 1.236 / 0.03 /
$ $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN	Country Sweden Germany UK Spain France Sweden Germany France	CA Reg-1 / 0.751 0.086 0.118 / 0.02 / 0.038	SE B Reg-2 / 0.862 0.111 0.153 / 0.02 / 0.047	Burn-up Reg-3 / 1.104 0.135 0.186 / 0.03 / 0.117	<pre>= 30 GV Reg-4 / 1.233 0.135 0.135 0.183 / 0.03 / 0.243</pre>	Wd/t - F Reg-5 / 3.969 0.066 0.597 / 0.03 / 0.521	P include Reg-6 / 26.22 0.135 4.943 / 0.25 / 0.018	d – Nine Reg-7 / 26.46 0.135 5.105 / 0.25 / 0.009	-zone pr Reg-8 / 21.75 0.111 4.249 / 0.2 / 0.004	ofile Reg-9 / 17.65 0.086 3.365 / 0.17 / 0.003	CASI Reg-1 / 7.403 0.074 0.679 / 0.13 / 0.004	E B' E Reg-2 9.055 0.095 0.901 / 0.16 / 0.005	Burn-up = Reg-3 / 12.22 0.12 1.149 / 0.21 / 0.013	= 30 GW Reg-4 / 14.93 0.138 1.279 / 0.24 / 0.029	d/t - No Reg-5 / 11.46 0.146 0.847 / 0.08 / 0.757	FP inclu Reg-6 / 15.22 0.138 2.216 / 0.06 / 0.117	ded – Ni Reg-7 / 12.46 0.12 2.015 / 0.05 / 0.046	ne-zone Reg-8 / 9.676 0.095 1.596 / 0.04 / 0.017	profile Reg-9 / 7.58 0.074 1.236 / 0.03 / 0.013
	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI	Country Sweden Germany UK Spain France Sweden Germany France Japan	CAS Reg-1 / 0.751 0.086 0.118 / 0.02 / 0.038 0.121	<b>SE B</b> Reg-2 / 0.862 0.111 0.153 / 0.02 / 0.047 0.15	Burn-up Reg-3 / 1.104 0.135 0.186 / 0.03 / 0.117 0.187	= 30 GV Reg-4 / 1.233 0.135 0.135 0.183 / 0.03 / 0.243 0.185	Wd/t - Fl Reg-5 / 3.969 0.066 0.597 / 0.03 / 0.521 0.053	P include Reg-6 / 26.22 0.135 4.943 / 0.25 / 0.018 0.092	d – Nine Reg-7 / 26.46 0.135 5.105 / 0.25 / 0.25 / 0.009 0.087	-zone pr Reg-8 / 21.75 0.111 4.249 / 0.2 / 0.004 0.07	ofile Reg-9 / 17.65 0.086 3.365 / 0.17 / 0.003 0.054	CASH Reg-1 / 7.403 0.074 0.679 / 0.13 / 0.004 0.071	E B' E Reg-2 9.055 0.095 0.901 / 0.16 / 0.005 0.09	Burn-up = Reg-3 / 12.22 0.12 1.149 / 0.21 / 0.013 0.119	- 30 GW Reg-4 / 14.93 0.138 1.279 / 0.24 / 0.24 / 0.029 0.133	d/t - No Reg-5 / 11.46 0.146 0.847 / 0.08 / 0.08 / 0.757 0.096	FP inclu Reg-6 / 15.22 0.138 2.216 / 0.06 / 0.117 0.156	ded – Ni Reg-7 / 12.46 0.12 2.015 / 0.05 / 0.046 0.14	ne-zone Reg-8 / 9.676 0.095 1.596 / 0.04 / 0.017 0.108	profile Reg-9 / 7.58 0.074 1.236 / 0.03 / 0.013 0.087
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan	CAS Reg-1 / 0.751 0.086 0.118 / 0.02 / 0.038 0.121 0.037	SE B Reg-2 / 0.862 0.111 0.153 / 0.02 / 0.047 0.15 0.046	Burn-up Reg-3 / 1.104 0.135 0.186 / 0.03 / 0.117 0.187 0.113	= 30 GV Reg-4 / 1.233 0.135 0.135 0.183 / 0.03 / 0.243 0.185 0.223	Wd/t - FI Reg-5 / 3.969 0.066 0.597 / 0.03 / 0.521 0.053 0.505	P include Reg-6 / 26.22 0.135 4.943 / 0.25 / 0.018 0.092 0.04	d – Nine Reg-7 / 26.46 0.135 5.105 / 0.25 / 0.009 0.087 0.021	-zone pr Reg-8 / 21.75 0.111 4.249 / 0.22 / 0.004 0.07 0.008	ofile Reg-9 / 17.65 0.086 3.365 / 0.17 / 0.003 0.054 0.007	CASH Reg-1 / 7.403 0.074 0.679 / 0.13 / 0.004 0.071 0.01	E B' E Reg-2 / 9.055 0.095 0.901 / 0.16 / 0.005 0.09 0.013	Burn-up = Reg-3 / 12.22 0.12 1.149 / 0.21 / 0.013 0.119 0.034	- 30 GW Reg-4 / 14.93 0.138 1.279 / 0.24 / 0.029 0.133 0.079	d/t - No Reg-5 / 11.46 0.146 0.847 / 0.0847 / 0.08 / 0.757 0.096 0.73	FP inclu Reg-6 / 15.22 0.138 2.216 / 0.006 / 0.117 0.156 0.077	ded – Ni Reg-7 / 12.46 0.12 2.015 / 0.05 / 0.046 0.14 0.034	ne-zone Reg-8 / 9.676 0.095 1.596 / 0.04 / 0.017 0.108 0.013	profile Reg-9 / 7.58 0.074 1.236 / 0.03 / 0.013 0.087 0.01
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan	CAS Reg-1 / 0.751 0.086 0.118 / 0.02 / 0.038 0.121 0.037 0.032	SE B           Reg-2           /           0.862           0.111           0.153           /           0.02           /           0.047           0.046           0.04	Burn-up Reg-3 / 1.104 0.135 0.186 / 0.03 / 0.117 0.187 0.113 0.097	= 30 GV Reg-4 / 1.233 0.135 0.135 0.183 / 0.03 / 0.243 0.185 0.223 0.194	Wd/t - Fi Reg-5 / 3.969 0.066 0.597 / 0.053 0.521 0.053 0.505 0.48	P include Reg-6 / 26.22 0.135 4.943 / 0.25 / 0.018 0.092 0.04 0.083	d – Nine Reg-7 / 26.46 0.135 5.105 / 0.25 / 0.009 0.087 0.021 0.042	-zone pr Reg-8 / 21.75 0.111 4.249 / 0.2 / 0.004 0.07 0.008 0.017	ofile Reg-9 / 17.65 0.086 3.365 / 0.17 / 0.003 0.054 0.007 0.014	CASI Reg-1 / 7.403 0.074 0.679 / 0.13 / 0.004 0.071 0.01 0.016	E B' E Reg-2 9.055 0.095 0.901 / 0.16 / 0.005 0.09 0.013 0.02	Burn-up = Reg-3 / 12.22 0.12 1.149 / 0.21 / 0.013 0.119 0.034 0.054	- 30 GW Reg-4 / 14.93 0.138 1.279 / 0.24 / 0.029 0.133 0.079 0.126	d/t - No Reg-5 / 11.46 0.146 0.847 / 0.084 / 0.757 0.096 0.73 0.688	FP inclu Reg-6 / 15.22 0.138 2.216 / 0.066 / 0.117 0.156 0.077 0.057	ded – Ni Reg-7 / 12.46 0.12 2.015 / 0.05 / 0.046 0.14 0.034 0.023	ne-zone Reg-8 / 9.676 0.095 1.596 / 0.04 / 0.017 0.108 0.013 0.009	profile Reg-9 / 7.58 0.074 1.236 / 0.03 / 0.013 0.087 0.01 0.007
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\     12 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA	CAS Reg-1 / 0.751 0.086 0.118 / 0.02 / 0.038 0.121 0.037 0.032 2E-06	SE B           Reg-2           /           0.862           0.111           0.153           /           0.02           /           0.047           0.046           0.04           2E-06	Burn-up Reg-3 / 1.104 0.135 0.186 / 0.03 / 0.117 0.187 0.113 0.097 3E-06	= 30 GV Reg-4 / 1.233 0.135 0.135 0.183 / 0.03 / 0.243 0.185 0.223 0.194 3E-06	Wd/t - Fi Reg-5 / 3.969 0.066 0.597 / 0.053 / 0.521 0.053 0.505 0.48 5E-07	P include Reg-6 / 26.22 0.135 4.943 / 0.25 / 0.018 0.092 0.04 0.083 6E-07	d – Nine Reg-7 / 26.46 0.135 5.105 / 0.25 / 0.009 0.087 0.021 0.042 6E-07	-zone pr Reg-8 / 21.75 0.111 4.249 / 0.2 / 0.004 0.07 0.008 0.017 5E-07	ofile Reg-9 / 17.65 0.086 3.365 / 0.17 / 0.003 0.054 0.007 0.014 4E-07	CASH Reg-1 / 7.403 0.074 0.679 / 0.13 / 0.004 0.071 0.01 0.016 7E-07	E B' F Reg-2 9.055 0.095 0.901 / 0.16 / 0.005 0.09 0.013 0.02 9E-07	Burn-up = Reg-3 / 12.22 0.12 1.149 / 0.21 / 0.013 0.119 0.034 0.054 1E-06	- 30 GW Reg-4 / 14.93 0.138 1.279 / 0.24 / 0.029 0.133 0.079 0.126 1E-06	d/t - No Reg-5 / 11.46 0.146 0.847 / 0.08 / 0.08 / 0.757 0.096 0.73 0.688 8E-07	PP inclu Reg-6 / 15.22 0.138 2.216 / 0.066 / 0.117 0.156 0.077 0.057 6E-07	ded – Ni Reg-7 / 12.46 0.12 2.015 / 0.05 / 0.046 0.14 0.034 0.023 6E-07	ne-zone Reg-8 / 9.676 0.095 1.596 / 0.04 / 0.017 0.017 0.108 0.013 0.009 4E-07	profile Reg-9 / 7.58 0.074 1.236 / 0.03 / 0.03 / 0.013 0.087 0.01 0.007 3E-07
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\     12 \\     13 \\   \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL PNC	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan	CAS Reg-1 / 0.751 0.086 0.118 / 0.02 / 0.038 0.121 0.037 0.032 2E-06 0.017	SE B           Reg-2           /           0.862           0.111           0.153           /           0.02           /           0.047           0.155           0.046           0.046           0.022	Burn-up Reg-3 / 1.104 0.135 0.186 / 0.03 / 0.117 0.117 0.113 0.097 3E-06 0.054	= 30 GV Reg-4 / 1.233 0.135 0.135 0.183 / 0.03 / 0.243 0.185 0.223 0.194 3E-06 0.104	Wd/t - Fl           Reg-5           /           3.969           0.066           0.597           /           0.03           /           0.521           0.053           0.505           0.48           5E-07           0.573	P include Reg-6 / 26.22 0.135 4.943 / 0.25 / 0.018 0.092 0.04 0.083 6E-07 0.122	d – Nine Reg-7 / 26.46 0.135 5.105 / 0.25 / 0.009 0.087 0.021 0.042 6E-07 0.063	-zone pr Reg-8 / 21.75 0.111 4.249 / 0.2 / 0.004 0.07 0.008 0.017 5E-07 0.025	ofile Reg-9 / 17.65 0.086 3.365 / 0.17 / 0.017 0.003 0.054 0.007 0.014 4E-07 0.02	CASI Reg-1 / 7.403 0.074 0.074 0.074 0.074 0.013 / 0.004 0.001 0.016 7E-07 0.009	E B' F Reg-2 9.055 0.095 0.901 / 0.16 / 0.005 0.09 0.013 0.02 9E-07 0.012	Burn-up = Reg-3 / 12.22 0.12 1.149 / 0.21 / 0.013 0.119 0.034 0.054 1E-06 0.031	= 30 GW Reg-4 / 14.93 0.138 1.279 / 0.24 / 0.029 0.133 0.079 0.126 1E-06 0.072	d/t - No Reg-5 / 11.46 0.146 0.847 / 0.084 / 0.757 0.096 0.73 0.688 8E-07 0.747	FP inclu Reg-6 / 15.22 0.138 2.216 / 0.06 / 0.117 0.156 0.077 0.057 6E-07 0.075	ded – Ni Reg-7 / 12.46 0.12 2.015 / 0.05 / 0.046 0.14 0.023 6E-07 0.032	ne-zone Reg-8 / 9.676 0.095 1.596 / 0.04 / 0.017 0.108 0.013 0.009 4E-07 0.012	profile Reg-9 / 7.58 0.074 1.236 / 0.03 / 0.03 0.013 0.087 0.011 0.007 3E-07 0.009

### Table 7. Fission densities/fractions as submitted by participants

This table gives the data as submitted by participants. Note that this data is not homogeneous since on the one hand two different definitions of fission distribution were used (fission density as defined in Eq. 1 or fission fraction as defined in Eq. 2), and on the other hand different normalisations were assumed. In Tables 9 and 10 the data is made homogeneous as discussed in Paragraph 4.

			C	ASE C	Burn-	up = 50 (	GWd/t -	FP inclu	ded - No	BU prof	ile	CAS	SE C'	Burn-u	p = 50 G	Wd/t - N	lo FP inc	luded - N	lo BU pr	ofile
#	Institute	Country	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9
1	ABB	Sweden																		
2	BfS-IKE	Germany	2.979	4.1	6.495	11.04	35.45	15.28	11.17	7.7	5.789	2.126	2.838	4.13	7.343	29.2	23.52	14.43	9.142	7.262
3	BNFL	UK	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
4	CSN	Spain	0.135	0.19	0.282	0.462	1.184	0.466	0.286	0.195	0.142	0.133	0.189	0.281	0.461	1.184	0.465	0.285	0.193	0.14
5	CEA	France	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
6	EMS	Sweden	0.03	0.04	0.07	0.1	0.23	0.23	0.14	0.09	0.07	0.05	0.07	0.11	0.2	0.34	0.1	0.05	0.04	0.03
7	GRS	Germany	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
8	IPSN	France	3E-04	4E-04	0.001	0.005	0.97	0.017	0.004	0.001	8E-04	4E-04	7E-04	0.003	0.01	0.904	0.057	0.016	0.005	0.004
9	JAERI	Japan	0.03	0.046	0.07	0.118	0.444	0.14	0.076	0.048	0.029	0.029	0.04	0.057	0.103	0.425	0.155	0.089	0.06	0.042
10	JINS-1	Japan	0.002	0.003	0.009	0.028	0.914	0.029	0.009	0.003	0.002	0.003	0.003	0.01	0.03	0.913	0.027	0.008	0.003	0.002
11	JINS-2	Japan	0.003	0.003	0.01	0.032	0.921	0.021	0.007	0.002	0.002	0.002	0.003	0.009	0.029	0.913	0.029	0.01	0.003	0.002
12	ORNL	USA	7E-08	1E-07	1E-07	2E-07	8E-07	4E-07	2E-07	1E-07	1E-07	1E-07	2E-07	3E-07	5E-07	9E-07	3E-07	2E-07	1E-07	1E-07
13	PNC	Japan	0.002	0.003	0.01	0.03	0.907	0.031	0.011	0.004	0.003	0.003	0.003	0.011	0.035	0.89	0.038	0.012	0.004	0.003
14	UKDOT	UK	0.042	0.057	0.087	0.163	0.339	0.135	0.083	0.056	0.039	0.042	0.056	0.089	0.159	0.377	0.123	0.07	0.047	0.036
			CA	SE D	Burn-up	0 = 50  GV	Wd/t – F	P include	ed – Nine	e-zone pr	ofile	CASE	E <b>D'</b> I	Burn-up =	= 50 GW	/d/t – No	FP inclu	ded – Ni	ne-zone	profile
#	Institute	Country	CA Reg-1	SE D Reg-2	Burn-up Reg-3	= 50  GV Reg-4	Wd/t – F Reg-5	P include Reg-6	ed – Nine Reg-7	e-zone pr Reg-8	ofile Reg-9	CASE Reg-1	E <b>D'</b> H Reg-2	Burn-up = Reg-3	= 50 GW Reg-4	/d/t – No Reg-5	FP inclu Reg-6	ided – Ni Reg-7	ne-zone Reg-8	profile Reg-9
#	Institute ABB	Country Sweden	CAS Reg-1	SE D Reg-2	Burn-up Reg-3	e = 50 GV Reg-4	Wd/t – F Reg-5 /	P include Reg-6	ed – Nine Reg-7 /	e-zone pr Reg-8 /	ofile Reg-9 /	CASE Reg-1	E <b>D'</b> H Reg-2	Burn-up = Reg-3 /	= 50 GW Reg-4 /	/d/t – No Reg-5 /	FP inclu Reg-6	ided – Ni Reg-7 /	ne-zone Reg-8 /	profile Reg-9 /
# 1 2	Institute ABB BfS-IKE	Country Sweden Germany	CA3 Reg-1 / 13.97	<b>SE D</b> Reg-2 / 16.58	Burn-up Reg-3 / 18.44	e = 50 GV Reg-4 / 14.56	Wd/t – Fl Reg-5 / 1.291	P include Reg-6 / 8.589	ed – Nine Reg-7 / 10.22	e-zone pr Reg-8 / 8.94	ofile Reg-9 / 7.415	CASI Reg-1 / 8.452	E <b>D'</b> H Reg-2 / 10.58	3urn-up = Reg-3 / 12.84	= 50 GW Reg-4 / 12.26	/d/t – No Reg-5 / 3.254	FP inclu Reg-6 / 13.94	nded – Ni Reg-7 / 15.14	ne-zone Reg-8 / 12.77	profile Reg-9 / 10.76
# 1 2 3	Institute ABB BfS-IKE BNFL	Country Sweden Germany UK	CA3 Reg-1 / 13.97 0.104	<b>SE D</b> Reg-2 / 16.58 0.131	Burn-up Reg-3 / 18.44 0.143	e = 50 GV Reg-4 / 14.56 0.11	Wd/t - F Reg-5 / 1.291 0.024	P include Reg-6 / 8.589 0.11	ed – Nine Reg-7 / 10.22 0.143	-zone pr Reg-8 / 8.94 0.131	ofile Reg-9 / 7.415 0.104	CASE Reg-1 / 8.452 0.09	E <b>D'</b> H Reg-2 / 10.58 0.115	Burn-up = Reg-3 / 12.84 0.136	= 50 GW Reg-4 / 12.26 0.128	Vd/t - No Reg-5 / 3.254 0.061	FP inclu Reg-6 / 13.94 0.128	nded – Ni Reg-7 / 15.14 0.136	Reg-8 / 12.77 0.115	profile Reg-9 / 10.76 0.09
# 1 2 3 4	Institute ABB BfS-IKE BNFL CSN	Country Sweden Germany UK Spain	CA Reg-1 / 13.97 0.104 0.009	<b>SE D</b> Reg-2 / 16.58 0.131 0.011	Burn-up Reg-3 / 18.44 0.143 0.012	e = 50 GV Reg-4 / 14.56 0.11 0.01	Wd/t - F Reg-5 / 1.291 0.024 0.324	P include Reg-6 / 8.589 0.11 6.198	ed – Nine Reg-7 / 10.22 0.143 8.068	e-zone pr Reg-8 / 8.94 0.131 7.419	ofile Reg-9 / 7.415 0.104 6.1	CASH Reg-1 / 8.452 0.09 0.037	E D' H Reg-2 / 10.58 0.115 0.047	3urn-up = Reg-3 / 12.84 0.136 0.055	= 50 GW Reg-4 / 12.26 0.128 0.051	Vd/t - No Reg-5 / 3.254 0.061 0.502	FP inclu Reg-6 / 13.94 0.128 5.542	ided – Ni Reg-7 / 15.14 0.136 6.159	ne-zone Reg-8 / 12.77 0.115 5.299	profile Reg-9 / 10.76 0.09 4.225
# 1 2 3 4 5	Institute ABB BfS-IKE BNFL CSN CEA	Country Sweden Germany UK Spain France	CA3 Reg-1 / 13.97 0.104 0.009 /	SE D Reg-2 / 16.58 0.131 0.011 /	Burn-up Reg-3 / 18.44 0.143 0.012 /	e = 50 GV Reg-4 / 14.56 0.11 0.01 /	Wd/t - F Reg-5 / 1.291 0.024 0.324 /	P include Reg-6 / 8.589 0.11 6.198 /	ed – Nine Reg-7 / 10.22 0.143 8.068 /	e-zone pr Reg-8 / 8.94 0.131 7.419 /	ofile Reg-9 / 7.415 0.104 6.1 /	CASH Reg-1 / 8.452 0.09 0.037 /	E D' F Reg-2 / 10.58 0.115 0.047 /	Burn-up = Reg-3 / 12.84 0.136 0.055 /	= 50 GW Reg-4 / 12.26 0.128 0.051 /	Vd/t - No Reg-5 / 3.254 0.061 0.502 /	FP inclu Reg-6 / 13.94 0.128 5.542 /	ided – N Reg-7 / 15.14 0.136 6.159 /	ne-zone Reg-8 / 12.77 0.115 5.299 /	profile Reg-9 / 10.76 0.09 4.225 /
$ $	Institute ABB BfS-IKE BNFL CSN CEA EMS	Country Sweden Germany UK Spain France Sweden	CA3 Reg-1 / 13.97 0.104 0.009 / 0.14	<b>SE D</b> Reg-2 / 16.58 0.131 0.011 / 0.16	Burn-up Reg-3 / 18.44 0.143 0.012 / 0.18	e = 50 GV Reg-4 / 14.56 0.11 0.01 / 0.14	Wd/t - F Reg-5 / 1.291 0.024 0.324 / 0.01	P include Reg-6 / 8.589 0.11 6.198 / 0.09	ed – Nine Reg-7 / 10.22 0.143 8.068 / 0.11	e-zone pr Reg-8 / 8.94 0.131 7.419 / 0.1	ofile Reg-9 / 7.415 0.104 6.1 / 0.08	CASI Reg-1 / 8.452 0.09 0.037 / 0.18	E D' F Reg-2 / 10.58 0.115 0.047 / 0.22	Burn-up = Reg-3 / 12.84 0.136 0.055 / 0.26	= 50 GW Reg-4 / 12.26 0.128 0.051 / 0.25	/d/t - No Reg-5 / 3.254 0.061 0.502 / 0.03	FP inclu Reg-6 / 13.94 0.128 5.542 / 0.02	ded – N Reg-7 / 15.14 0.136 6.159 / 0.02	ne-zone Reg-8 / 12.77 0.115 5.299 / 0.02	profile Reg-9 / 10.76 0.09 4.225 / 0.01
	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS	Country Sweden Germany UK Spain France Sweden Germany	CA3 Reg-1 / 13.97 0.104 0.009 / 0.14 /	SE D Reg-2 / 16.58 0.131 0.011 / 0.16 /	Burn-up Reg-3 / 18.44 0.143 0.012 / 0.18 /	e = 50 GV Reg-4 / 14.56 0.11 0.01 / 0.14 /	Wd/t - F Reg-5 / 1.291 0.024 0.324 / 0.01 /	P include Reg-6 / 8.589 0.11 6.198 / 0.09 /	ed – Nine Reg-7 / 10.22 0.143 8.068 / 0.11 /	e-zone pr Reg-8 / 8.94 0.131 7.419 / 0.1 /	ofile Reg-9 / 7.415 0.104 6.1 / 0.08 /	CASI Reg-1 / 8.452 0.09 0.037 / 0.18 /	E D' F Reg-2 / 10.58 0.115 0.047 / 0.22 /	Burn-up = Reg-3 / 12.84 0.136 0.055 / 0.26 /	= 50 GW Reg-4 / 12.26 0.128 0.051 / 0.25 /	/d/t - No Reg-5 / 3.254 0.061 0.502 / 0.03 /	FP inclu Reg-6 / 13.94 0.128 5.542 / 0.02 /	ided - N Reg-7 / 15.14 0.136 6.159 / 0.02 /	ne-zone Reg-8 / 12.77 0.115 5.299 / 0.02 /	profile Reg-9 / 10.76 0.09 4.225 / 0.01 /
	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN	Country Sweden Germany UK Spain France Sweden Germany France	CA3 Reg-1 / 13.97 0.104 0.009 / 0.14 / 0.081	SE D Reg-2 / 16.58 0.131 0.011 / 0.16 / 0.095	Burn-up Reg-3 / 18.44 0.143 0.012 / 0.18 / 0.214	b = 50 GV Reg-4 / 14.56 0.11 0.01 / 0.14 / 0.336	Wd/t - F Reg-5 / 1.291 0.024 0.324 / 0.01 / 0.253	P include Reg-6 / 8.589 0.11 6.198 / 0.09 / 0.009	ed – Nine Reg-7 / 10.22 0.143 8.068 / 0.11 / 0.007	-zone pr Reg-8 / 8.94 0.131 7.419 / 0.1 / 0.003	ofile Reg-9 / 7.415 0.104 6.1 / 0.08 / 0.002	CASI Reg-1 / 8.452 0.09 0.037 / 0.18 / 0.032	E D' H Reg-2 / 10.58 0.115 0.047 / 0.22 / 0.041	Burn-up = Reg-3 / 12.84 0.136 0.055 / 0.26 / 0.102	= 50 GW Reg-4 / 12.26 0.128 0.051 / 0.25 / 0.19	/d/t - No Reg-5 / 3.254 0.061 0.502 / 0.03 / 0.439	FP inclu Reg-6 / 13.94 0.128 5.542 / 0.02 / 0.101	ided - N Reg-7 / 15.14 0.136 6.159 / 0.02 / 0.025	ne-zone Reg-8 / 12.77 0.115 5.299 / 0.02 / 0.022	profile Reg-9 / 10.76 0.09 4.225 / 0.01 / 0.017
	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI	Country Sweden Germany UK Spain France Sweden Germany France Japan	CA3 Reg-1 / 13.97 0.104 0.009 / 0.14 0.081 0.14	SE D Reg-2 / 16.58 0.131 0.011 / 0.16 / 0.095 0.165	Burn-up Reg-3 / 18.44 0.143 0.012 / 0.18 / 0.214 0.183	= 50 GV Reg-4 / 14.56 0.11 0.01 / 0.14 / 0.336 0.142	Wd/t - Fl Reg-5 / 1.291 0.024 0.324 / 0.01 / 0.253 0.012	P include Reg-6 / 8.589 0.11 6.198 / 0.09 / 0.009 0.08	d - Nine Reg-7 / 10.22 0.143 8.068 / 0.111 / 0.007 0.103	-zone pr Reg-8 / 8.94 0.131 7.419 / 0.1 / 0.003 0.094	ofile Reg-9 / 7.415 0.104 6.1 / 0.08 / 0.002 0.081	CASI Reg-1 / 8.452 0.09 0.037 / 0.18 / 0.032 0.053	E D' H Reg-2 / 10.58 0.115 0.047 / 0.22 / 0.041 0.065	Burn-up = Reg-3 / 12.84 0.136 0.055 / 0.26 / 0.26 / 0.102 0.078	= 50 GW Reg-4 / 12.26 0.128 0.051 / 0.25 / 0.19 0.073	d/t - No Reg-5 / 3.254 0.061 0.502 / 0.03 / 0.439 0.026	FP inclu Reg-6 / 13.94 0.128 5.542 / 0.02 / 0.101 0.188	ded – N Reg-7 / 15.14 0.136 6.159 / 0.02 / 0.025 0.204	ne-zone Reg-8 / 12.77 0.115 5.299 / 0.02 / 0.022 0.172	profile Reg-9 / 10.76 0.09 4.225 / 0.01 / 0.017 0.141
$ $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan	CA3 Reg-1 / 13.97 0.104 0.009 / 0.14 0.14 0.041	SE D Reg-2 / 16.58 0.131 0.011 / 0.016 / 0.095 0.165 0.048	Burn-up Reg-3 / 18.44 0.143 0.012 / 0.18 / 0.214 0.183 0.109	<pre>&gt; = 50 GV Reg-4 / 14.56 0.11 0.01 / 0.14 / 0.336 0.142 0.174</pre>	Wd/t - F Reg-5 / 1.291 0.024 0.324 / 0.01 / 0.253 0.012 0.285	P include Reg-6 / 8.589 0.11 6.198 / 0.09 / 0.009 0.08 0.161	d - Nine Reg-7 / 10.22 0.143 8.068 / 0.111 / 0.007 0.103 0.1	-zone pr Reg-8 / 8.94 0.131 7.419 / 0.1 / 0.003 0.094 0.044	ofile Reg-9 / 7.415 0.104 6.1 / 0.004 0.002 0.002 0.081 0.037	CASI Reg-1 / 8.452 0.09 0.037 / 0.18 / 0.032 0.053 0.018	E D' H Reg-2 / 10.58 0.115 0.047 / 0.047 / 0.041 0.065 0.021	Burn-up : Reg-3 / 12.84 0.136 0.055 / 0.26 / 0.102 0.078 0.052	= 50 GW Reg-4 / 12.26 0.128 0.051 / 0.25 / 0.19 0.073 0.099	d/t - No Reg-5 / 3.254 0.061 0.502 / 0.03 / 0.439 0.026 0.471	FP inclu Reg-6 / 13.94 0.128 5.542 / 0.02 / 0.101 0.188 0.177	ided - N           Reg-7           /           15.14           0.136           6.159           /           0.02           /           0.055           0.204           0.091	ne-zone Reg-8 / 12.77 0.115 5.299 / 0.022 0.022 0.172 0.039	profile Reg-9 / 10.76 0.09 4.225 / 0.01 / 0.017 0.141 0.032
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan	CA3 Reg-1 / 13.97 0.104 0.009 / 0.14 0.081 0.14 0.041 0.036	SE D Reg-2 / 16.58 0.131 0.011 / 0.005 0.165 0.048 0.041	Burn-up Reg-3 / 18.44 0.143 0.012 / 0.18 0.214 0.183 0.109 0.093	= 50 GV Reg-4 / 14.56 0.11 0.01 / 0.14 0.336 0.142 0.174 0.15	Wd/t - F Reg-5 / 1.291 0.024 0.324 / 0.01 / 0.253 0.012 0.285 0.292	P include Reg-6 / 8.589 0.11 6.198 / 0.09 / 0.009 0.08 0.161 0.183	d - Nine Reg-7 / 10.22 0.143 8.068 / 0.11 / 0.007 0.103 0.1 0.112	-zone pr Reg-8 / 8.94 0.131 7.419 / 0.1 / 0.003 0.094 0.044 0.05	ofile Reg-9 / 7.415 0.104 6.1 / 0.08 / 0.002 0.081 0.037 0.043	CASI Reg-1 / 8.452 0.09 0.037 / 0.18 / 0.032 0.053 0.018 0.018	E D' H Reg-2 / 10.58 0.115 0.047 / 0.047 / 0.041 0.065 0.021 0.022	Burn-up 3 Reg-3 / 12.84 0.136 0.055 / 0.26 / 0.102 0.078 0.052 0.051	= 50 GW Reg-4 / 12.26 0.128 0.051 / 0.25 / 0.19 0.073 0.099 0.095	d/t - No Reg-5 / 3.254 0.061 0.502 / 0.03 / 0.439 0.026 0.471 0.464	FP inclu Reg-6 / 13.94 0.128 5.542 / 0.02 / 0.101 0.188 0.177 0.186	ded - N Reg-7 / 15.14 0.136 6.159 / 0.02 / 0.055 0.204 0.091 0.095	ne-zone Reg-8 / 12.77 0.115 5.299 / 0.022 0.172 0.039 0.038	profile Reg-9 / 10.76 0.09 4.225 / 0.01 / 0.017 0.141 0.032 0.032
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\     12 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA	CA3 Reg-1 / 13.97 0.104 0.009 / 0.14 / 0.081 0.14 0.041 0.036 8E-07	SE D           Reg-2           /           16.58           0.131           0.011           /           0.16           /           0.095           0.165           0.048           0.041           1E-06	Burn-up Reg-3 / 18.44 0.143 0.012 / 0.18 / 0.214 0.183 0.109 0.093 1E-06	= 50 GV Reg-4 / 14.56 0.11 0.01 / 0.14 0.142 0.174 0.15 9E-07	Wd/t - F Reg-5 / 1.291 0.024 0.324 / 0.01 / 0.253 0.012 0.285 0.292 2E-07	P include Reg-6 / 8.589 0.11 6.198 / 0.09 / 0.009 / 0.009 0.08 0.161 0.183 3E-06	d - Nine Reg-7 / 10.22 0.143 8.068 / 0.11 / 0.007 0.103 0.1 0.112 4E-06	-zone pr Reg-8 / 8.94 0.131 7.419 / 0.1 / 0.003 0.094 0.044 0.05 4E-06	ofile Reg-9 / 7,415 0.104 6.1 / 0.008 / 0.002 0.081 0.037 0.043 3E-06	CASI Reg-1 / 8.452 0.09 0.037 / 0.18 / 0.032 0.053 0.018 0.018 9E-07	E D' H Reg-2 / 10.58 0.115 0.047 / 0.047 / 0.041 0.065 0.021 0.022 1E-06	Burn-up : Reg-3 / 12.84 0.136 0.055 / 0.266 / 0.102 0.078 0.052 0.051 1E-06	= 50 GW Reg-4 / 12.26 0.128 0.051 / 0.25 / 0.19 0.073 0.099 0.095 1E-06	d/t - No Reg-5 / 3.254 0.061 0.502 / 0.03 / 0.439 0.026 0.471 0.464 4E-07	FP inclu Reg-6 / 13.94 0.128 5.542 / 0.02 / 0.101 0.188 0.177 0.186 3E-06	ded – N Reg-7 / 15.14 0.136 6.159 / 0.02 / 0.055 0.204 0.091 0.095 3E-06	ne-zone Reg-8 / 12.77 0.115 5.299 / 0.022 / 0.022 0.172 0.039 0.038 3E-06	profile Reg-9 / 10.76 0.09 4.225 / 0.01 / 0.017 0.141 0.032 0.032 2E-06
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\     12 \\     13 \\   \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL PNC	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan	CA Reg-1 / 13.97 0.104 0.009 / 0.14 0.14 0.081 0.14 0.036 8E-07 0.04	SE D           Reg-2           /           16.58           0.131           0.011           /           0.16           /           0.095           0.165           0.048           0.041           1E-06           0.048	Burn-up Reg-3 / 18.44 0.143 0.012 / 0.18 / 0.214 0.183 0.109 0.093 1E-06 0.106	= 50 GV Reg-4 / 14.56 0.11 0.01 / 0.14 / 0.336 0.142 0.174 0.15 9E-07 0.173	Wd/t - Fi Reg-5 / 1.291 0.024 0.324 / 0.01 / 0.253 0.012 0.285 0.292 2E-07 0.316	P include Reg-6 / 8.589 0.11 6.198 / 0.09 / 0.009 / 0.009 0.08 0.161 0.183 3E-06 0.147	d - Nine Reg-7 / 10.22 0.143 8.068 / 0.11 / 0.007 0.103 0.1 0.112 4E-06 0.093	-zone pr Reg-8 / 8.94 0.131 7.419 / 0.1 / 0.003 0.094 0.044 0.05 4E-06 0.042	ofile Reg-9 / 7.415 0.104 6.1 / 0.08 / 0.002 0.081 0.037 0.043 3E-06 0.035	CASI Reg-1 / 8.452 0.09 0.037 / 0.18 / 0.032 0.053 0.018 0.018 9E-07 0.021	E D' H Reg-2 / 10.58 0.115 0.047 / 0.047 / 0.047 / 0.041 0.065 0.021 0.022 1E-06 0.026	Burn-up : Reg-3 / 12.84 0.136 0.055 / 0.26 / 0.102 0.078 0.052 0.051 1E-06 0.063	= 50 GW Reg-4 / 12.26 0.128 0.051 / 0.25 / 0.19 0.073 0.099 0.095 1E-06 0.121	d/t - No Reg-5 / 3.254 0.061 0.502 / 0.03 / 0.439 0.026 0.471 0.464 4E-07 0.525	FP inclu Reg-6 / 13.94 0.128 5.542 / 0.02 / 0.101 0.188 0.177 0.186 3E-06 0.131	ided - N           Reg-7           /           15.14           0.136           6.159           /           0.02           /           0.055           0.204           0.091           0.095           3E-06           0.065	ne-zone Reg-8 / 12.77 0.115 5.299 / 0.022 0.022 0.172 0.039 0.038 3E-06 0.026	profile Reg-9 / 10.76 0.09 4.225 / 0.01 / 0.017 0.141 0.032 0.032 2E-06 0.022

### Table 7. Fission densities/fractions as submitted by participants (cont.)

This table gives the data as submitted by participants. Note that this data is not homogeneous since on the one hand two different definitions of fission distribution were used (fission density as defined in Eq. 1 or fission fraction as defined in Eq. 2), and on the other hand different normalisations were assumed. In Tables 9 and 10 the data is made homogeneous as discussed in Paragraph 4.

					CASE	E					
					Fresh f	uel					
#	Institute	e Country	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9
1	ABB	Sweden	/	/	/	/	/	/	/	/	/
2	BfS-IKI	E Germany	4.339	5.726	9.22	14.17	28.8	15.91	9.604	6.692	5.536
3	BNFL	UK	/	/	/	/	/	/	/	/	/
4	CSN	Spain	0.133	0.189	0.286	0.461	1.184	0.465	0.285	0.193	0.139
5	CEA	France	/	/	/	/	/	/	/	/	/
6	EMS	Sweden	0.06	0.08	0.12	0.18	0.26	0.13	0.08	0.06	0.04
7	GRS	Germany	/	/	/	/	/	/	/	/	/
8	IPSN	France	0.001	0.002	0.006	0.024	0.935	0.022	0.006	0.002	0.001
9	JAERI	Japan	0.029	0.042	0.066	0.121	0.454	0.127	0.076	0.048	0.037
10	JINS-1	Japan	0.002	0.003	0.008	0.026	0.923	0.025	0.008	0.003	0.002
11	JINS-2	Japan	0.002	0.002	0.007	0.023	0.925	0.027	0.009	0.003	0.002
12	ORNL	USA	2E-07	2E-07	3E-07	4E-07	1E-06	8E-07	5E-07	4E-07	3E-07
13	PNC	Japan	0.002	0.003	0.008	0.026	0.91	0.035	0.011	0.004	0.002
14	UKDOT	ГUK	0.042	0.059	0.086	0.139	0.364	0.126	0.085	0.057	0.042

Table 7. Fission densities/fractions as submitted by participants (cont.)

This table gives the data as submitted by participants. Note that this data is not homogeneous since on the one hand two different definitions of fission distribution were used (fission density as defined in Eq. 1 or fission fraction as defined in Eq. 2), and on the other hand different normalisations were assumed. In Tables 9 and 10 the data is made homogeneous as discussed in Paragraph 4.

			CA	SE A	Burn-u	p = 30 G	₩d/t – I	FP incluc	led – No	BU prof	ïles	CAS	E A'	Burn-up	= 30  GV	Vd/t - N	o FP incl	luded – N	lo BU pi	ofiles
#	Institute	Country	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9
1	ABB	Sweden	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
2	<b>BfS-IKE</b>	Germany	0.065	0.079	0.112	0.165	0.274	0.124	0.088	0.052	0.041	0.018	0.039	0.038	0.069	0.391	0.195	0.111	0.077	0.061
3	BNFL	UK	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
4	CSN	Spain	0.040	0.057	0.084	0.138	0.354	0.139	0.086	0.058	0.043	0.040	0.056	0.084	0.138	0.353	0.139	0.090	0.058	0.042
5	CEA	France	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
6	EMS	Sweden	0.049	0.059	0.088	0.137	0.275	0.147	0.108	0.078	0.059	0.051	0.061	0.091	0.152	0.273	0.152	0.101	0.071	0.051
7	GRS	Germany	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
8	IPSN	France	0.001	0.001	0.002	0.009	0.932	0.039	0.011	0.003	0.002	0.001	0.002	0.005	0.024	0.942	0.017	0.006	0.002	0.001
9	JAERI	Japan	0.041	0.060	0.084	0.124	0.361	0.138	0.085	0.062	0.045	0.037	0.051	0.079	0.136	0.483	0.099	0.057	0.034	0.023
10	JINS-1	Japan	0.002	0.003	0.007	0.022	0.898	0.045	0.014	0.005	0.004	0.002	0.003	0.010	0.033	0.912	0.027	0.008	0.003	0.002
11	JINS-2	Japan	0.002	0.003	0.010	0.030	0.918	0.024	0.007	0.003	0.002	0.002	0.003	0.008	0.027	0.920	0.026	0.008	0.003	0.002
12	ORNL	USA	0.059	0.072	0.112	0.182	0.352	0.092	0.057	0.041	0.032	0.056	0.078	0.118	0.187	0.352	0.090	0.055	0.039	0.025
13	PNC	Japan	0.003	0.004	0.011	0.034	0.905	0.029	0.009	0.003	0.002	0.002	0.003	0.009	0.027	0.910	0.034	0.010	0.003	0.002
14	UKDOT	UK	0.012	0.015	0.023	0.038	0.340	0.243	0.149	0.099	0.081	0.048	0.062	0.091	0.150	0.365	0.124	0.076	0.049	0.035
			CAS	SE B	Burn-up	0 = 30  GV	Wd/t – Fl	P include	d – Nine	e-zone pr	ofile	CASE	E <b>B'</b> E	Burn-up =	= 30 GW	/d/t – No	FP inclu	ided – Ni	ne-zone	profile
#	Institute	Country	CAS Reg-1	SE B Reg-2	Burn-up Reg-3	= 30 GV Reg-4	Wd/t – Fl Reg-5	P include Reg-6	d – Nine Reg-7	-zone pr Reg-8	ofile Reg-9	CASH Reg-1	E <b>B'</b> H Reg-2	Burn-up = Reg-3	= 30 GW Reg-4	/d/t – No Reg-5	FP inclu Reg-6	ided – Ni Reg-7	ne-zone Reg-8	profile Reg-9
#	Institute ABB	Country Sweden	CAS Reg-1	<b>SE B</b> Reg-2	Burn-up Reg-3	= 30 GV Reg-4	Wd/t – Fl Reg-5 /	P include Reg-6 /	ed – Nine Reg-7 /	-zone pr Reg-8 /	ofile Reg-9 /	CASE Reg-1	E <b>B'</b> E Reg-2	Burn-up = Reg-3 /	= 30 GW Reg-4 /	/d/t – No Reg-5 /	FP inclu Reg-6	ided – Ni Reg-7 /	ne-zone Reg-8 /	profile Reg-9 /
# 1 2	Institute ABB BfS-IKE	Country Sweden Germany	CA3 Reg-1 / 0.008	SE B Reg-2 / 0.009	Burn-up Reg-3 / 0.011	= 30 GV Reg-4 / 0.012	Wd/t - Fl Reg-5 / 0.040	P include Reg-6 / 0.262	ed – Nine Reg-7 / 0.265	-zone pr Reg-8 / 0.217	ofile Reg-9 / 0.177	CASI Reg-1 / 0.074	E <b>B'</b> F Reg-2 / 0.091	Burn-up = Reg-3 / 0.122	= 30 GW Reg-4 / 0.149	Vd/t - No Reg-5 / 0.115	FP inclu Reg-6 / 0.152	ided – Ni Reg-7 / 0.125	ne-zone Reg-8 / 0.097	profile Reg-9 / 0.076
# 1 2 3	Institute ABB BfS-IKE BNFL	Country Sweden Germany UK	CA3 Reg-1 / 0.008 /	SE B Reg-2 / 0.009 /	Burn-up Reg-3 / 0.011 /	= 30 GV Reg-4 / 0.012 /	Wd/t - Fl Reg-5 / 0.040 /	P include Reg-6 / 0.262 /	ed – Nine Reg-7 / 0.265 /	-zone pr Reg-8 / 0.217 /	ofile Reg-9 / 0.177 /	CASE Reg-1 / 0.074 /	E B' F Reg-2 / 0.091 /	3urn-up = Reg-3 / 0.122 /	= 30 GW Reg-4 / 0.149 /	Vd/t – No Reg-5 / 0.115 /	FP inclu Reg-6 / 0.152 /	ided – Ni Reg-7 / 0.125 /	ne-zone Reg-8 / 0.097 /	profile Reg-9 / 0.076 /
# 1 2 3 4	Institute ABB BfS-IKE BNFL CSN	Country Sweden Germany UK Spain	CA3 Reg-1 / 0.008 / 0.006	<b>SE B</b> Reg-2 / 0.009 / 0.008	Burn-up Reg-3 / 0.011 / 0.010	= 30 GV Reg-4 / 0.012 / 0.010	Wd/t - Fl Reg-5 / 0.040 / 0.032	P include Reg-6 / 0.262 / 0.262	rd – Nine Reg-7 / 0.265 / 0.270	-zone pr Reg-8 / 0.217 / 0.225	ofile Reg-9 / 0.177 / 0.178	CASI Reg-1 / 0.074 / 0.057	E <b>B'</b> E Reg-2 / 0.091 / 0.076	Burn-up = Reg-3 / 0.122 / 0.096	= 30 GW Reg-4 / 0.149 / 0.107	Vd/t - No Reg-5 / 0.115 / 0.071	FP inclu Reg-6 / 0.152 / 0.186	ided – Ni Reg-7 / 0.125 / 0.169	ne-zone Reg-8 / 0.097 / 0.134	profile Reg-9 / 0.076 / 0.104
$ $	Institute ABB BfS-IKE BNFL CSN CEA	Country Sweden Germany UK Spain France	CAS Reg-1 / 0.008 / 0.006 /	SE B Reg-2 / 0.009 / 0.008 /	Burn-up Reg-3 / 0.011 / 0.010 /	e = 30 GV Reg-4 / 0.012 / 0.010 /	Wd/t - Fl Reg-5 / 0.040 / 0.032 /	P include Reg-6 / 0.262 / 0.262 /	d – Nine Reg-7 / 0.265 / 0.270 /	-zone pr Reg-8 / 0.217 / 0.225 /	ofile Reg-9 / 0.177 / 0.178 /	CASI Reg-1 / 0.074 / 0.057 /	E B' F Reg-2 / 0.091 / 0.076 /	Burn-up = Reg-3 / 0.122 / 0.096 /	= 30 GW Reg-4 / 0.149 / 0.107 /	7d/t - No Reg-5 / 0.115 / 0.071 /	FP inclu Reg-6 / 0.152 / 0.186 /	ided – Ni Reg-7 / 0.125 / 0.169 /	ne-zone Reg-8 / 0.097 / 0.134 /	profile Reg-9 / 0.076 / 0.104 /
$ $	Institute ABB BfS-IKE BNFL CSN CEA EMS	Country Sweden Germany UK Spain France Sweden	CA3 Reg-1 / 0.008 / 0.006 / 0.020	SE B Reg-2 / 0.009 / 0.008 / 0.020	Burn-up Reg-3 / 0.011 / 0.010 / 0.030	= 30 GV Reg-4 / 0.012 / 0.010 / 0.030	Wd/t - Fl Reg-5 / 0.040 / 0.032 / 0.030	P include Reg-6 / 0.262 / 0.262 / 0.250	d – Nine Reg-7 / 0.265 / 0.270 / 0.250	-zone pr Reg-8 / 0.217 / 0.225 / 0.200	ofile Reg-9 / 0.177 / 0.178 / 0.170	CASI Reg-1 / 0.074 / 0.057 / 0.130	E <b>B'</b> E Reg-2 / 0.091 / 0.076 / 0.160	Burn-up = Reg-3 / 0.122 / 0.096 / 0.210	= 30 GW Reg-4 / 0.149 / 0.107 / 0.240	7d/t - No Reg-5 / 0.115 / 0.071 / 0.080	FP inclu Reg-6 / 0.152 / 0.186 / 0.060	ided – Ni Reg-7 / 0.125 / 0.169 / 0.050	ne-zone Reg-8 / 0.097 / 0.134 / 0.040	profile Reg-9 / 0.076 / 0.104 / 0.030
	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS	Country Sweden Germany UK Spain France Sweden Germany	CAS Reg-1 / 0.008 / 0.006 / 0.020 /	SE B Reg-2 / 0.009 / 0.008 / 0.020 /	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 /	= 30 GV Reg-4 / 0.012 / 0.010 / 0.030 /	Wd/t - Fl Reg-5 / 0.040 / 0.032 / 0.030 /	P include Reg-6 / 0.262 / 0.262 / 0.250 /	d – Nine Reg-7 / 0.265 / 0.270 / 0.250 /	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 /	ofile Reg-9 / 0.177 / 0.178 / 0.170 /	CASI Reg-1 / 0.074 / 0.057 / 0.130 /	E B' E Reg-2 / 0.091 / 0.076 / 0.160 /	Burn-up = Reg-3 / 0.122 / 0.096 / 0.210 /	= 30 GW Reg-4 / 0.149 / 0.107 / 0.240 /	7d/t - No Reg-5 / 0.115 / 0.071 / 0.080 /	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 /	ided – Ni Reg-7 / 0.125 / 0.169 / 0.050 /	ne-zone Reg-8 / 0.097 / 0.134 / 0.040 /	profile Reg-9 / 0.076 / 0.104 / 0.030 /
$ $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN	Country Sweden Germany UK Spain France Sweden Germany France	CA Reg-1 / 0.008 / 0.006 / 0.020 / 0.038	SE B Reg-2 / 0.009 / 0.008 / 0.020 / 0.047	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.117	= 30 GV Reg-4 / 0.012 / 0.010 / 0.030 / 0.243	Wd/t - Fl Reg-5 / 0.040 / 0.032 / 0.030 / 0.521	P include Reg-6 / 0.262 / 0.262 / 0.250 / 0.018	d – Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.009	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.004	ofile Reg-9 / 0.177 / 0.178 / 0.170 / 0.003	CASI Reg-1 / 0.074 / 0.057 / 0.130 / 0.004	E B' E Reg-2 / 0.091 / 0.076 / 0.160 / 0.005	Burn-up = Reg-3 / 0.122 / 0.096 / 0.210 / 0.013	= 30 GW Reg-4 / 0.149 / 0.107 / 0.240 / 0.029	d/t – No Reg-5 / 0.115 / 0.071 / 0.080 / 0.757	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.117	nded – Ni Reg-7 / 0.125 / 0.169 / 0.050 / 0.046	ne-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.017	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.013
$ $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI	Country Sweden Germany UK Spain France Sweden Germany France Japan	CAS Reg-1 / 0.008 / 0.006 / 0.020 / 0.0238 0.121	<b>SE B</b> Reg-2 / 0.009 / 0.008 / 0.020 / 0.020 / 0.047 0.150	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.117 0.187	= 30 GV Reg-4 / 0.012 / 0.010 / 0.030 / 0.243 0.185	Wd/t - Fl Reg-5 / 0.040 / 0.032 / 0.030 / 0.521 0.053	P include Reg-6 / 0.262 / 0.262 / 0.250 / 0.250 / 0.018 0.092	d – Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.250 / 0.009 0.087	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.200 / 0.004 0.070	ofile Reg-9 / 0.177 / 0.178 / 0.170 / 0.003 0.054	CASI Reg-1 / 0.074 / 0.057 / 0.130 / 0.004 0.071	E B' E Reg-2 / 0.091 / 0.076 / 0.160 / 0.005 0.090	Burn-up : Reg-3 / 0.122 / 0.096 / 0.210 / 0.210 0.013 0.119	= 30 GW Reg-4 / 0.149 / 0.107 / 0.240 / 0.029 0.133	d/t - No Reg-5 / 0.115 / 0.071 / 0.080 / 0.757 0.096	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.117 0.156	nded – Ni Reg-7 / 0.125 / 0.169 / 0.050 / 0.050 / 0.046 0.140	ne-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.040 / 0.017 0.108	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.030 / 0.013 0.087
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan	CAS Reg-1 / 0.008 / 0.006 / 0.020 / 0.020 / 0.038 0.121 0.037	<b>SE B</b> Reg-2 / 0.009 / 0.008 / 0.020 / 0.047 0.150 0.046	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.117 0.187 0.113	= 30 GV Reg-4 / 0.012 / 0.010 / 0.030 / 0.243 0.185 0.223	Wd/t - Fl Reg-5 / 0.040 / 0.032 / 0.030 / 0.521 0.053 0.505	P include Reg-6 / 0.262 / 0.262 / 0.250 / 0.018 0.092 0.040	d – Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.250 / 0.009 0.087 0.021	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.200 / 0.004 0.070 0.008	ofile Reg-9 / 0.177 / 0.178 / 0.170 / 0.003 0.054 0.007	CASI Reg-1 / 0.074 / 0.057 / 0.130 / 0.004 0.071 0.010	E B' E Reg-2 / 0.091 / 0.076 / 0.160 / 0.005 0.090 0.013	Burn-up = Reg-3 / 0.122 / 0.096 / 0.210 / 0.210 / 0.013 0.119 0.034	= 30 GW Reg-4 / 0.149 / 0.107 / 0.240 / 0.029 0.133 0.079	d/t - No Reg-5 / 0.115 / 0.071 / 0.080 / 0.757 0.096 0.730	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.117 0.156 0.077	nded – Ni Reg-7 / 0.125 / 0.169 / 0.050 / 0.046 0.140 0.034	ne-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.040 / 0.017 0.108 0.013	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.013 0.087 0.010
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan	CAS Reg-1 / 0.008 / 0.006 / 0.020 / 0.038 0.121 0.037 0.032	<b>SE B</b> <b>Reg-2</b> / 0.009 / 0.008 / 0.020 / 0.047 0.150 0.046 0.040	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.117 0.187 0.113 0.097	= 30 GV Reg-4 / 0.012 / 0.010 / 0.030 / 0.243 0.185 0.223 0.194	Wd/t - Fl Reg-5 / 0.040 / 0.032 / 0.030 / 0.521 0.053 0.505 0.480	P include Reg-6 / 0.262 / 0.262 / 0.250 / 0.250 / 0.018 0.092 0.040 0.083	d - Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.250 / 0.009 0.087 0.021 0.042	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.200 / 0.004 0.070 0.008 0.017	ofile Reg-9 / 0.177 / 0.178 / 0.170 / 0.003 0.054 0.007 0.014	CASI Reg-1 / 0.074 / 0.057 / 0.130 / 0.004 0.071 0.010 0.016	E B' F Reg-2 / 0.091 / 0.076 / 0.160 / 0.005 0.090 0.013 0.020	Burn-up 3 Reg-3 / 0.122 / 0.096 / 0.210 / 0.210 / 0.013 0.119 0.034 0.054	= 30 GW Reg-4 / 0.149 / 0.107 / 0.240 / 0.029 0.133 0.079 0.126	d/t - No Reg-5 / 0.115 / 0.071 / 0.080 / 0.757 0.096 0.730 0.688	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.117 0.156 0.077 0.057	ided – Ni Reg-7 / 0.125 / 0.169 / 0.050 / 0.046 0.140 0.034 0.023	ne-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.040 / 0.017 0.108 0.013 0.009	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.013 0.087 0.010 0.007
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\     12 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA	CAS Reg-1 / 0.008 / 0.006 / 0.020 / 0.038 0.121 0.037 0.032 0.154	<b>SE B</b> <b>Reg-2</b> / 0.009 / 0.008 / 0.020 / 0.047 0.150 0.046 0.040 0.189	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.117 0.117 0.113 0.097 0.229	= 30 GV Reg-4 / 0.012 / 0.010 / 0.030 / 0.243 0.185 0.223 0.194 0.231	Wd/t - Fl Reg-5 / 0.040 / 0.032 / 0.030 / 0.521 0.053 0.505 0.480 0.040	P include Reg-6 / 0.262 / 0.262 / 0.250 / 0.018 0.092 0.040 0.083 0.046	d – Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.250 / 0.009 0.087 0.021 0.042 0.045	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.004 0.070 0.008 0.017 0.036	ofile Reg-9 / 0.177 / 0.178 / 0.170 / 0.003 0.054 0.007 0.014 0.030	CASH Reg-1 / 0.074 / 0.057 / 0.130 / 0.004 0.071 0.010 0.016 0.102	E B' F Reg-2 / 0.091 / 0.076 / 0.160 / 0.005 0.090 0.013 0.020 0.128	Burn-up = Reg-3 / 0.122 / 0.096 / 0.210 / 0.210 / 0.013 0.119 0.034 0.054 0.168	= 30 GW Reg-4 / 0.149 / 0.107 / 0.240 / 0.029 0.133 0.079 0.126 0.192	d/t - No Reg-5 / 0.115 / 0.071 / 0.080 / 0.757 0.096 0.730 0.688 0.121	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.117 0.156 0.077 0.057 0.093	ided – Ni Reg-7 / 0.125 / 0.169 / 0.050 / 0.046 0.140 0.034 0.023 0.082	ne-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.017 0.108 0.013 0.009 0.064	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.013 0.087 0.010 0.007 0.051
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\     12 \\     13 \\   \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL PNC	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan	CAS Reg-1 / 0.008 / 0.006 / 0.020 / 0.038 0.121 0.037 0.032 0.154 0.017	<b>SE B</b> Reg-2 / 0.009 / 0.008 / 0.020 / 0.047 0.150 0.046 0.040 0.189 0.022	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.117 0.187 0.113 0.097 0.229 0.054	<pre>= 30 GV Reg-4 / 0.012 / 0.010 / 0.030 / 0.243 0.185 0.223 0.194 0.231 0.104</pre>	Wd/t - Fl Reg-5 / 0.040 / 0.032 / 0.030 / 0.521 0.053 0.505 0.480 0.040 0.573	P include Reg-6 / 0.262 / 0.262 / 0.250 / 0.018 0.092 0.040 0.083 0.046 0.122	d – Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.250 / 0.009 0.087 0.021 0.042 0.045 0.063	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.200 / 0.004 0.070 0.008 0.017 0.036 0.025	ofile Reg-9 / 0.177 / 0.178 / 0.170 / 0.003 0.054 0.007 0.014 0.030 0.020	CASH Reg-1 / 0.074 / 0.057 / 0.130 / 0.004 0.071 0.010 0.016 0.102 0.009	E B' F Reg-2 / 0.091 / 0.076 / 0.160 / 0.005 0.090 0.013 0.020 0.128 0.012	Burn-up = Reg-3 / 0.122 / 0.096 / 0.210 / 0.210 / 0.013 0.119 0.034 0.054 0.054 0.031	= 30 GW Reg-4 / 0.149 / 0.107 / 0.240 / 0.029 0.133 0.079 0.126 0.192 0.072	d/t - No Reg-5 / 0.115 / 0.071 / 0.080 / 0.757 0.096 0.730 0.688 0.121 0.748	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.117 0.156 0.077 0.057 0.093 0.075	ided – Ni Reg-7 / 0.125 / 0.169 / 0.050 / 0.046 0.140 0.034 0.023 0.082 0.032	ne-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.040 0.017 0.108 0.013 0.009 0.064 0.012	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.030 / 0.013 0.087 0.010 0.007 0.051 0.009

### Table 8. Normalised fission densities/fractions

Normalised fission distributions are reported in this table. The results of each participant and for each case are normalised to unity. Note that this data is still heterogeneous since BfS-IKE, CSN, EMS, JAERI, ORNL and UKDOT results are fission densities (see Eq. 1) while IPSN, JINS-1, JINS-2 and PNC results are fission fractions (see Eq. 2).

			CA	<b>SEC</b>	Burn-u	p = 50 C	3Wd/t − !	FP incluc	ded – No	BU prot	file	CAS	SE C'	Burn-up	b = 50  G	Wd/t - N	o FP inc	luded – I	No BU p	rofile
#	Institute	Country	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9
1	ABB	Sweden	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
2	<b>BfS-IKE</b>	Germany	0.030	0.041	0.065	0.110	0.355	0.153	0.112	0.077	0.058	0.021	0.028	0.041	0.073	0.292	0.235	0.144	0.091	0.073
3	BNFL	UK	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
4	CSN	Spain	0.040	0.057	0.084	0.138	0.354	0.140	0.086	0.058	0.043	0.040	0.057	0.084	0.138	0.355	0.140	0.086	0.058	0.042
5	CEA	France	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
6	EMS	Sweden	0.030	0.040	0.070	0.100	0.230	0.230	0.140	0.090	0.070	0.051	0.071	0.111	0.202	0.343	0.101	0.051	0.040	0.030
7	GRS	Germany	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
8	IPSN	France	0.000	0.000	0.001	0.005	0.970	0.017	0.004	0.001	0.001	0.000	0.001	0.003	0.010	0.904	0.057	0.016	0.005	0.004
9	JAERI	Japan	0.030	0.046	0.070	0.118	0.444	0.140	0.076	0.048	0.029	0.029	0.040	0.057	0.103	0.425	0.155	0.089	0.060	0.042
10	JINS-1	Japan	0.002	0.003	0.009	0.028	0.914	0.029	0.009	0.003	0.002	0.003	0.003	0.010	0.030	0.913	0.027	0.008	0.003	0.002
11	JINS-2	Japan	0.003	0.003	0.010	0.032	0.921	0.021	0.007	0.002	0.002	0.002	0.003	0.009	0.029	0.913	0.029	0.010	0.003	0.002
12	ORNL	USA	0.032	0.046	0.067	0.108	0.360	0.167	0.100	0.067	0.054	0.052	0.068	0.106	0.165	0.318	0.118	0.076	0.054	0.043
13	PNC	Japan	0.002	0.003	0.010	0.030	0.906	0.031	0.011	0.004	0.003	0.003	0.003	0.011	0.035	0.891	0.038	0.012	0.004	0.003
14	UKDOT	UK	0.042	0.057	0.087	0.163	0.339	0.135	0.083	0.056	0.039	0.042	0.056	0.089	0.159	0.377	0.123	0.070	0.047	0.036
	·		CAS	SE D	Burn-up	= 50 GV	Vd/t – Fl	? include	d – Nine	-zone pr	ofile	CASE	E D' E	urn-up =	= 50 GW	d/t – No	FP inclu	ded – Ni	ne-zone	profile
#	Institute	Country	CAS Reg-1	SE D Reg-2	Burn-up Reg-3	= 50  GV Reg-4	Vd/t – Fl Reg-5	P include Reg-6	d – Nine Reg-7	-zone pr Reg-8	ofile Reg-9	CASE Reg-1	E D' E Reg-2	urn-up = Reg-3	= 50 GW Reg-4	d/t – No Reg-5	FP inclu Reg-6	ded – Ni Reg-7	ne-zone Reg-8	profile Reg-9
#	Institute ABB	Country Sweden	CAS Reg-1	SE D Reg-2	Burn-up Reg-3	= 50 GV Reg-4	Wd/t – Fl Reg-5	P include Reg-6 /	ed – Nine Reg-7 /	e-zone pr Reg-8 /	ofile Reg-9 /	CASE Reg-1	E D' E Reg-2 /	Burn-up = Reg-3 /	= 50 GW Reg-4 /	d/t – No Reg-5 /	FP inclu Reg-6	ded – Ni Reg-7 /	ne-zone Reg-8	profile Reg-9 /
# 1 2	Institute ABB BfS-IKE	Country Sweden Germany	CA: Reg-1 / 0.140	<b>SE D</b> Reg-2 / 0.166	Burn-up Reg-3 / 0.184	= 50 GV Reg-4 / 0.146	Wd/t - Fi Reg-5 / 0.013	P include Reg-6 / 0.086	ed – Nine Reg-7 / 0.102	-zone pr Reg-8 / 0.089	ofile Reg-9 / 0.074	CASH Reg-1 / 0.085	E D' E Reg-2 / 0.106	Burn-up = Reg-3 / 0.128	= 50 GW Reg-4 / 0.123	d/t - No Reg-5 / 0.033	FP inclu Reg-6 / 0.139	ded – Ni Reg-7 / 0.151	ne-zone Reg-8 / 0.128	profile Reg-9 / 0.108
# 1 2 3	Institute ABB BfS-IKE BNFL	Country Sweden Germany UK	CA: Reg-1 / 0.140 /	SE D Reg-2 / 0.166 /	Burn-up Reg-3 / 0.184 /	e = 50 GV Reg-4 / 0.146 /	Wd/t - Fi Reg-5 / 0.013 /	P include Reg-6 / 0.086 /	ed – Nine Reg-7 / 0.102 /	-zone pr Reg-8 / 0.089 /	ofile Reg-9 / 0.074 /	CASE Reg-1 / 0.085 /	E D' E Reg-2 / 0.106 /	Burn-up = Reg-3 / 0.128 /	= 50 GW Reg-4 / 0.123 /	d/t - No Reg-5 / 0.033 /	FP inclu Reg-6 / 0.139 /	ded – Ni Reg-7 / 0.151 /	ne-zone Reg-8 / 0.128 /	profile Reg-9 / 0.108 /
# 1 2 3 4	Institute ABB BfS-IKE BNFL CSN	Country Sweden Germany UK Spain	CA: Reg-1 / 0.140 / 0.000	SE D Reg-2 / 0.166 / 0.000	Burn-up Reg-3 / 0.184 / 0.000	e = 50 GV Reg-4 / 0.146 / 0.000	Wd/t - F. Reg-5 / 0.013 / 0.012	P include Reg-6 / 0.086 / 0.220	ed – Nine Reg-7 / 0.102 / 0.287	-zone pr Reg-8 / 0.089 / 0.264	ofile Reg-9 / 0.074 / 0.217	CASH Reg-1 / 0.085 / 0.002	E D' E Reg-2 / 0.106 / 0.002	Burn-up = Reg-3 / 0.128 / 0.003	= 50 GW Reg-4 / 0.123 / 0.002	d/t - No Reg-5 / 0.033 / 0.023	FP inclu Reg-6 / 0.139 / 0.253	ded – Ni Reg-7 / 0.151 / 0.281	ne-zone Reg-8 / 0.128 / 0.242	profile Reg-9 / 0.108 / 0.193
	Institute ABB BfS-IKE BNFL CSN CEA	Country Sweden Germany UK Spain France	CA: Reg-1 / 0.140 / 0.000 /	SE D Reg-2 / 0.166 / 0.000 /	Burn-up Reg-3 / 0.184 / 0.000 /	e = 50 GV Reg-4 / 0.146 / 0.000 /	Wd/t - F Reg-5 / 0.013 / 0.012 /	P include Reg-6 / 0.086 / 0.220 /	rd – Nine Reg-7 / 0.102 / 0.287 /	-zone pr Reg-8 / 0.089 / 0.264 /	ofile Reg-9 / 0.074 / 0.217 /	CASE Reg-1 / 0.085 / 0.002 /	E D' E Reg-2 / 0.106 / 0.002 /	Burn-up = Reg-3 / 0.128 / 0.003 /	= 50 GW Reg-4 / 0.123 / 0.002 /	d/t - No Reg-5 / 0.033 / 0.023 /	FP inclu Reg-6 / 0.139 / 0.253 /	ded – Ni Reg-7 / 0.151 / 0.281 /	ne-zone Reg-8 / 0.128 / 0.242 /	profile Reg-9 / 0.108 / 0.193 /
$ $	Institute ABB BfS-IKE BNFL CSN CEA EMS	Country Sweden Germany UK Spain France Sweden	CA: Reg-1 / 0.140 / 0.000 / 0.139	SE D Reg-2 / 0.166 / 0.000 / 0.158	Burn-up Reg-3 / 0.184 / 0.000 / 0.178	e = 50 GV Reg-4 / 0.146 / 0.000 / 0.139	Wd/t - F Reg-5 / 0.013 / 0.012 / 0.010	P include Reg-6 / 0.086 / 0.220 / 0.089	ed – Nine Reg-7 / 0.102 / 0.287 / 0.109	-zone pr Reg-8 / 0.089 / 0.264 / 0.099	ofile Reg-9 / 0.074 / 0.217 / 0.079	CASH Reg-1 / 0.085 / 0.002 / 0.178	E D' E Reg-2 / 0.106 / 0.002 / 0.218	Burn-up = Reg-3 / 0.128 / 0.003 / 0.257	= 50 GW Reg-4 / 0.123 / 0.002 / 0.248	d/t - No Reg-5 / 0.033 / 0.023 / 0.023 / 0.030	FP inclu Reg-6 / 0.139 / 0.253 / 0.020	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020	ne-zone Reg-8 / 0.128 / 0.242 / 0.020	profile Reg-9 / 0.108 / 0.193 / 0.010
# 1 2 3 4 5 6 7	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS	Country Sweden Germany UK Spain France Sweden Germany	CA: Reg-1 / 0.140 / 0.000 / 0.139 /	SE D Reg-2 / 0.166 / 0.000 / 0.158 /	Burn-ur Reg-3 / 0.184 / 0.000 / 0.178 /	b = 50 GV Reg-4 / 0.146 / 0.000 / 0.139 /	Wd/t - F Reg-5 / 0.013 / 0.012 / 0.010 /	P include Reg-6 / 0.086 / 0.220 / 0.089 /	ed – Nine Reg-7 / 0.102 / 0.287 / 0.109 /	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 /	ofile Reg-9 / 0.074 / 0.217 / 0.079 /	CASH Reg-1 / 0.085 / 0.002 / 0.178 /	E D' E Reg-2 / 0.106 / 0.002 / 0.218 /	Burn-up = Reg-3 / 0.128 / 0.003 / 0.257 /	= 50 GW Reg-4 / 0.123 / 0.002 / 0.248 /	d/t - No Reg-5 / 0.033 / 0.023 / 0.030 /	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 /	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 /	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 /	profile Reg-9 / 0.108 / 0.193 / 0.010 /
	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN	Country Sweden Germany UK Spain France Sweden Germany France	CA: Reg-1 / 0.140 / 0.000 / 0.139 / 0.081	SE D Reg-2 / 0.166 / 0.000 / 0.158 / 0.095	Burn-ur Reg-3 / 0.184 / 0.000 / 0.178 / 0.214	b = 50 GV Reg-4 / 0.146 / 0.000 / 0.139 / 0.336	Wd/t - F Reg-5 / 0.013 / 0.012 / 0.010 / 0.254	P include Reg-6 / 0.086 / 0.220 / 0.089 / 0.009	rd – Nine Reg-7 / 0.102 / 0.287 / 0.109 / 0.007	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.003	ofile Reg-9 / 0.074 / 0.217 / 0.079 / 0.002	CASH Reg-1 / 0.085 / 0.002 / 0.178 / 0.032	E D' E Reg-2 / 0.106 / 0.002 / 0.218 / 0.041	Burn-up = Reg-3 / 0.128 / 0.003 / 0.257 / 0.102	= 50 GW Reg-4 / 0.123 / 0.002 / 0.248 / 0.190	d/t - No Reg-5 / 0.033 / 0.023 / 0.030 / 0.439	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.101	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.055	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.022	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.017
$ \begin{array}{c}             \# \\             1 \\           $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI	Country Sweden Germany UK Spain France Sweden Germany France Japan	CA: Reg-1 / 0.140 / 0.000 / 0.139 / 0.081 0.140	SE D Reg-2 / 0.166 / 0.000 / 0.158 / 0.095 0.165	Burn-ur Reg-3 / 0.184 / 0.000 / 0.178 / 0.214 0.183	b = 50 GV Reg-4 / 0.146 / 0.000 / 0.139 / 0.336 0.142	Wd/t - Fl Reg-5 / 0.013 / 0.012 / 0.010 / 0.254 0.012	P include Reg-6 / 0.086 / 0.220 / 0.089 / 0.009 0.080	d – Nine Reg-7 / 0.102 / 0.287 / 0.287 / 0.109 / 0.007 0.103	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.003 0.094	ofile Reg-9 / 0.074 / 0.217 / 0.079 / 0.002 0.081	CASH Reg-1 / 0.085 / 0.002 / 0.078 / 0.032 0.053	E D' E Reg-2 / 0.106 / 0.002 / 0.218 / 0.041 0.065	Burn-up = Reg-3 / 0.128 / 0.003 / 0.257 / 0.102 0.078	= 50 GW Reg-4 / 0.123 / 0.002 / 0.248 / 0.190 0.073	d/t - No Reg-5 / 0.033 / 0.023 / 0.030 / 0.439 0.026	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.101 0.188	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.055 0.203	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.022 0.172	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.017 0.141
$     \begin{array}{r}             \# \\             1 \\           $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan	CA: Reg-1 / 0.140 / 0.000 / 0.139 / 0.081 0.140 0.041	SE D Reg-2 / 0.166 / 0.000 / 0.158 / 0.095 0.165 0.048	Burn-ur Reg-3 / 0.184 / 0.000 / 0.178 / 0.214 0.183 0.109	b = 50 GV Reg-4 / 0.146 / 0.000 / 0.139 / 0.336 0.142 0.174	Wd/t - Fl Reg-5 / 0.013 / 0.012 / 0.010 / 0.254 0.012 0.285	P include Reg-6 / 0.086 / 0.220 / 0.089 / 0.009 0.080 0.161	d – Nine Reg-7 / 0.102 / 0.287 / 0.109 / 0.007 0.103 0.100	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.003 0.094 0.044	ofile Reg-9 / 0.074 / 0.217 / 0.079 / 0.002 0.081 0.037	CASE Reg-1 / 0.085 / 0.002 / 0.178 / 0.032 0.053 0.018	E D' E Reg-2 / 0.106 / 0.002 / 0.218 / 0.041 0.065 0.021	Burn-up = Reg-3 / 0.128 / 0.003 / 0.257 / 0.102 0.078 0.052	= 50 GW Reg-4 / 0.123 / 0.002 / 0.248 / 0.190 0.073 0.099	d/t - No Reg-5 / 0.033 / 0.023 / 0.023 / 0.030 / 0.439 0.026 0.471	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.101 0.188 0.177	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.025 0.203 0.091	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.022 0.172 0.039	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.017 0.141 0.032
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan	CA: Reg-1 / 0.140 / 0.000 / 0.139 / 0.081 0.140 0.041 0.036	SE D Reg-2 / 0.166 / 0.000 / 0.158 / 0.095 0.165 0.048 0.041	Burn-ur Reg-3 / 0.184 / 0.000 / 0.178 / 0.214 0.183 0.109 0.093	D = 50 GV Reg-4 / 0.146 / 0.000 / 0.139 / 0.336 0.142 0.174 0.150	Wd/t - F Reg-5 / 0.013 / 0.012 / 0.010 / 0.254 0.012 0.285 0.292	P include Reg-6 / 0.086 / 0.220 / 0.089 / 0.009 0.080 0.161 0.183	d - Nine Reg-7 / 0.102 / 0.287 / 0.109 / 0.100 0.103 0.100 0.112	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.003 0.094 0.044 0.050	ofile Reg-9 / 0.074 / 0.217 / 0.079 / 0.002 0.081 0.037 0.043	CASE Reg-1 / 0.085 / 0.002 / 0.002 / 0.078 / 0.032 0.053 0.018 0.018	E D' E Reg-2 / 0.106 / 0.002 / 0.0218 / 0.041 0.065 0.021 0.022	Burn-up = Reg-3 / 0.128 / 0.003 / 0.003 / 0.257 / 0.102 0.078 0.052 0.051	= 50 GW Reg-4 / 0.123 / 0.002 / 0.248 / 0.190 0.073 0.099 0.095	d/t - No Reg-5 / 0.033 / 0.023 / 0.023 / 0.030 / 0.439 0.026 0.471 0.464	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.101 0.188 0.177 0.186	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.055 0.203 0.091 0.094	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.022 0.172 0.039 0.038	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.017 0.141 0.032 0.032
$ \begin{array}{c}             \# \\             1 \\           $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA	CA: Reg-1 / 0.140 / 0.000 / 0.139 / 0.081 0.140 0.041 0.036 0.044	SE D Reg-2 / 0.166 / 0.000 / 0.158 / 0.095 0.165 0.048 0.041 0.053	Burn-ur Reg-3 / 0.184 / 0.000 / 0.178 / 0.214 0.183 0.109 0.093 0.061	= 50 GV           Reg-4           /           0.146           /           0.000           /           0.139           /           0.336           0.142           0.174           0.150           0.049	Wd/t - F Reg-5 / 0.013 / 0.012 / 0.010 / 0.254 0.012 0.285 0.292 0.013	P include Reg-6 / 0.086 / 0.220 / 0.089 / 0.009 0.080 0.161 0.183 0.177	d - Nine Reg-7 / 0.102 / 0.287 / 0.109 / 0.100 0.103 0.100 0.112 0.223	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.003 0.094 0.044 0.050 0.204	ofile Reg-9 / 0.074 / 0.217 / 0.079 / 0.002 0.081 0.037 0.043 0.176	CASE Reg-1 / 0.085 / 0.002 / 0.002 / 0.078 / 0.032 0.053 0.018 0.018 0.057	E D' E Reg-2 / 0.106 / 0.002 / 0.218 / 0.041 0.065 0.021 0.022 0.067	Burn-up = Reg-3 / 0.128 / 0.003 / 0.003 / 0.257 / 0.102 0.078 0.052 0.051 0.080	= 50 GW Reg-4 / 0.123 / 0.002 / 0.248 / 0.190 0.073 0.099 0.095 0.074	d/t - No Reg-5 / 0.033 / 0.023 / 0.023 / 0.030 / 0.439 0.026 0.471 0.464 0.027	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.101 0.188 0.177 0.186 0.187	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.055 0.203 0.091 0.094 0.199	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.022 0.172 0.039 0.038 0.167	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.017 0.141 0.032 0.032 0.141
$ \begin{array}{c}             \# \\             1 \\           $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL PNC	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan	CA: Reg-1 / 0.140 / 0.000 / 0.139 / 0.081 0.041 0.036 0.044 0.040	SE D Reg-2 / 0.166 / 0.000 / 0.158 / 0.095 0.165 0.048 0.041 0.053 0.048	Burn-ur Reg-3 / 0.184 / 0.000 / 0.178 / 0.214 0.183 0.109 0.093 0.061 0.106	= 50 GV           Reg-4           /           0.146           /           0.000           /           0.139           /           0.336           0.142           0.174           0.150           0.049           0.173	Wd/t - F Reg-5 / 0.013 / 0.012 / 0.010 / 0.254 0.012 0.285 0.292 0.013 0.316	P include Reg-6 / 0.086 / 0.220 / 0.089 / 0.009 0.080 0.161 0.183 0.177 0.147	d - Nine Reg-7 / 0.102 / 0.287 / 0.109 / 0.103 0.100 0.112 0.223 0.093	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.003 0.094 0.044 0.050 0.204 0.042	ofile Reg-9 / 0.074 / 0.217 / 0.079 / 0.002 0.081 0.037 0.043 0.176 0.035	CASF Reg-1 / 0.085 / 0.002 / 0.078 / 0.032 0.053 0.018 0.018 0.057 0.021	E D' E Reg-2 / 0.106 / 0.002 / 0.218 / 0.041 0.041 0.065 0.021 0.022 0.067 0.026	Burn-up = Reg-3 / 0.128 / 0.003 / 0.257 / 0.102 0.078 0.052 0.051 0.080 0.063	= 50 GW Reg-4 / 0.123 / 0.002 / 0.248 / 0.190 0.073 0.099 0.095 0.074 0.121	d/t - No Reg-5 / 0.033 / 0.023 / 0.023 / 0.030 / 0.439 0.026 0.471 0.464 0.027 0.525	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.101 0.188 0.177 0.186 0.187 0.131	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.055 0.203 0.091 0.094 0.199 0.065	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.022 0.039 0.038 0.167 0.026	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.017 0.141 0.032 0.032 0.141 0.022

### Table 8. Normalised fission densities/fractions (cont.)

Normalised fission distributions are reported in this table. The results of each participant and for each case are normalised to unity. Note that this data is still heterogeneous since BfS-IKE, CSN, EMS, JAERI, ORNL and UKDOT results are fission densities (see Eq. 1) while IPSN, JINS-1, JINS-2 and PNC results are fission fractions (see Eq. 2).

					CASE	E					
					Fresh f	uel					
#	Institute	Country	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9
1	ABB	Sweden	/	/	/	/	/	/	/	/	/
2	BfS-IKE	Germany	0.043	0.057	0.092	0.142	0.288	0.159	0.096	0.067	0.055
3	BNFL	UK	/	/	/	/	/	/	/	/	/
4	CSN	Spain	0.040	0.057	0.086	0.138	0.355	0.139	0.085	0.058	0.042
5	CEA	France	/	/	/	/	/	/	/	/	/
6	EMS	Sweden	0.059	0.079	0.119	0.178	0.257	0.129	0.079	0.059	0.040
7	GRS	Germany	/	/	/	/	/	/	/	/	/
8	IPSN	France	0.001	0.002	0.006	0.024	0.935	0.022	0.006	0.002	0.001
9	JAERI	Japan	0.029	0.042	0.066	0.121	0.454	0.127	0.076	0.048	0.037
10	JINS-1	Japan	0.002	0.003	0.008	0.026	0.923	0.025	0.008	0.003	0.002
11	JINS-2	Japan	0.002	0.002	0.007	0.022	0.925	0.027	0.009	0.003	0.002
12	ORNL	USA	0.038	0.047	0.067	0.106	0.264	0.196	0.129	0.086	0.068
13	PNC	Japan	0.002	0.003	0.008	0.026	0.909	0.035	0.011	0.004	0.002
14	UKDOT	UK	0.042	0.059	0.086	0.139	0.364	0.126	0.085	0.057	0.042

Table 8. Normalised fission densities/fractions (cont.)

Normalised fission distributions are reported in this table. The results of each participant and for each case are normalised to unity. Note that this data is still heterogeneous since BfS-IKE, CSN, EMS, JAERI, ORNL and UKDOT results are fission densities (see Eq. 1) while IPSN, JINS-1, JINS-2 and PNC results are fission fractions (see Eq. 2).

## Table 9. Normalised fission fractions

			CA	SE A	Burn-uj	p = 30 G	Wd/t – I	FP inclue	ded – No	BU pro	file	CASE	E A' E	urn-up =	= 30 GW	d/t - Nc	FP incl	uded – N	lo BU p	rofiles
#	Institute	Country	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9
1	ABB	Sweden	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
2	BfS-IKE	Germany	0.004	0.005	0.013	0.038	0.897	0.028	0.010	0.003	0.002	0.001	0.002	0.003	0.012	0.935	0.033	0.009	0.003	0.003
3	BNFL	UK	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
4	CSN	Spain	0.002	0.003	0.008	0.025	0.925	0.025	0.008	0.003	0.002	0.002	0.003	0.008	0.025	0.924	0.025	0.008	0.003	0.002
5	CEA	France	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
6	EMS	Sweden	0.003	0.003	0.010	0.031	0.898	0.034	0.012	0.004	0.003	0.003	0.003	0.010	0.035	0.895	0.035	0.012	0.004	0.003
7	GRS	Germany	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
8	IPSN	France	0.001	0.001	0.002	0.009	0.932	0.039	0.011	0.003	0.002	0.001	0.002	0.005	0.024	0.942	0.017	0.006	0.002	0.001
9	JAERI	Japan	0.002	0.003	0.008	0.022	0.928	0.025	0.008	0.003	0.002	0.001	0.002	0.005	0.019	0.953	0.014	0.004	0.001	0.001
10	JINS-1	Japan	0.002	0.003	0.007	0.022	0.898	0.045	0.014	0.005	0.004	0.002	0.003	0.010	0.033	0.912	0.027	0.008	0.003	0.002
11	JINS-2	Japan	0.002	0.003	0.010	0.030	0.918	0.024	0.007	0.003	0.002	0.002	0.003	0.008	0.027	0.920	0.026	0.008	0.003	0.002
12	ORNL	USA	0.003	0.003	0.010	0.033	0.925	0.017	0.005	0.002	0.001	0.003	0.004	0.011	0.034	0.924	0.017	0.005	0.002	0.001
13	PNC	Japan	0.003	0.004	0.011	0.034	0.905	0.029	0.009	0.003	0.002	0.002	0.003	0.009	0.027	0.910	0.034	0.010	0.003	0.002
14	UKDOT	UK	0.001	0.001	0.002	0.007	0.921	0.046	0.014	0.005	0.004	0.002	0.003	0.008	0.027	0.928	0.022	0.007	0.002	0.002
		Average	0.002	0.003	0.008	0.025	0.915	0.031	0.010	0.003	0.002	0.002	0.003	0.008	0.026	0.924	0.025	0.008	0.003	0.002
		2 * <b>G</b> .	86%	80%	78%	74%	3%	55%	54%	55%	61%	63%	51%	58%	49%	3%	54%	54%	62%	66%
		1		0070	1010	1.10	070	0070	0.70		01/0	0070	/ -	0070	. > / 0	070	0.70	/ -	~ _ / *	0070
	L	- •1	CAS	EB E	Burn-up	$= 30 \mathrm{GW}$	Vd/t - FF	o include	ed – Nine	e-zone pi	ofile	CASE	B' Bu	rn-up =	30 GWd	l/t - No	FP inclue	ded – No	one-zone	profile
#	Institute	Country	CAS Reg-1	<b>E B</b> E Reg-2	Burn-up Reg-3	= 30 GW Reg-4	Vd/t – FF Reg-5	include Reg-6	d – Nine Reg-7	-zone pi Reg-8	rofile Reg-9	CASE Reg-1	<b>B'</b> Bu Reg-2	rn-up = Reg-3	30 GWc Reg-4	l/t – No 1 Reg-5	FP inclue Reg-6	ded – No Reg-7	one-zone Reg-8	profile Reg-9
#	Institute ABB	Country Sweden	CAS Reg-1	<b>E B</b> E Reg-2	Burn-up Reg-3	= 30 GW Reg-4	/d/t – FF Reg-5 /	P include Reg-6	ed – Nine Reg-7	e-zone pi Reg-8	rofile Reg-9	CASE Reg-1	<b>B'</b> Bu Reg-2	$\frac{\text{rn-up} =}{\text{Reg-3}}$	30 GWc Reg-4	l/t – No Reg-5	FP inclue Reg-6	ded – No Reg-7 /	ne-zone Reg-8	profile Reg-9
# 1 2	Institute ABB BfS-IKE	Country Sweden Germany	CAS Reg-1 / 0.002	<b>E B</b> H Reg-2 / 0.002	Burn-up = Reg-3 / 0.005	= 30 GW Reg-4 / 0.011	Vd/t – FF Reg-5 / 0.524	• include Reg-6 / 0.242	ed – Nine Reg-7 / 0.122	e-zone pi Reg-8 / 0.050	rofile Reg-9 / 0.041	CASE Reg-1 / 0.009	<b>B'</b> Bu Reg-2 / 0.011	rn-up = <u>Reg-3</u> / 0.028	30 GWc Reg-4 / 0.070	/t – No Reg-5 / 0.763	FP inclue Reg-6 / 0.071	ded – No Reg-7 / 0.029	ne-zone Reg-8 / 0.011	profile Reg-9 / 0.009
# 1 2 3	Institute ABB BfS-IKE BNFL	Country Sweden Germany UK	CAS Reg-1 / 0.002 /	E B H Reg-2 / 0.002 /	Burn-up = Reg-3 / 0.005 /	= 30 GW Reg-4 / 0.011 /	Vd/t – FF Reg-5 / 0.524 /	Pinclude Reg-6 / 0.242 /	ed – Nine Reg-7 / 0.122 /	e-zone pi Reg-8 / 0.050 /	rofile Reg-9 / 0.041 /	CASE Reg-1 / 0.009 /	<b>B'</b> Bu Reg-2 / 0.011 /	rr-up = Reg-3 / 0.028 /	30 GWa Reg-4 / 0.070 /	I/t - No I Reg-5 / 0.763 /	FP includ Reg-6 / 0.071 /	ded – No Reg-7 / 0.029 /	0.011 /	e profile Reg-9 / 0.009 /
# 1 2 3 4	Institute ABB BfS-IKE BNFL CSN	Country Sweden Germany UK Spain	CAS Reg-1 / 0.002 / 0.002	<b>E B</b> E Reg-2 / 0.002 / 0.002	Burn-up Reg-3 / 0.005 / 0.005	= 30 GW Reg-4 / 0.011 / 0.010	Vd/t - FF Reg-5 / 0.524 / 0.467	include           Reg-6           /           0.242           /           0.271	ed – Nine Reg-7 / 0.122 / 0.140	-zone pr Reg-8 / 0.050 / 0.058	ofile Reg-9 / 0.041 / 0.046	CASE Reg-1 / 0.009 / 0.009	B' Bu Reg-2 / 0.011 / 0.012	m-up = Reg-3 / 0.028 / 0.031	30 GWc Reg-4 / 0.070 / 0.070	/t - No ] Reg-5 / 0.763 / 0.662	FP inclue Reg-6 / 0.071 / 0.121	ded – No Reg-7 / 0.029 / 0.055	ne-zone Reg-8 / 0.011 / 0.022	profile Reg-9 / 0.009 / 0.017
	Institute ABB BfS-IKE BNFL CSN CEA	Country Sweden Germany UK Spain France	CAS Reg-1 / 0.002 / 0.002 /	EB F Reg-2 / 0.002 / 0.002 /	Burn-up = Reg-3 / 0.005 / 0.005 /	= 30 GW Reg-4 / 0.011 / 0.010 /	Vd/t - FF Reg-5 / 0.524 / 0.467 /	include           Reg-6           /           0.242           /           0.271	ed – Nine Reg-7 / 0.122 / 0.140 /	-zone pr Reg-8 / 0.050 / 0.058 /	offile           Reg-9           /           0.041           /           0.046	CASE Reg-1 / 0.009 / 0.009 /	B' Bu Reg-2 / 0.011 / 0.012 /	rn-up = <u>Reg-3</u> / 0.028 / 0.031 /	30 GWc Reg-4 / 0.070 / 0.070 /	//t - No ] Reg-5 / 0.763 / 0.662 /	FP includ Reg-6 / 0.071 / 0.121 /	ded – No Reg-7 / 0.029 / 0.055 /	ne-zone Reg-8 / 0.011 / 0.022 /	profile Reg-9 / 0.009 / 0.017 /
$ $	Institute ABB BfS-IKE BNFL CSN CEA EMS	Country Sweden Germany UK Spain France Sweden	CAS Reg-1 / 0.002 / 0.002 / 0.005	EB F Reg-2 / 0.002 / 0.002 / 0.005	Burn-up 3 Reg-3 / 0.005 / 0.005 / 0.005 / 0.016	= 30 GW Reg-4 / 0.011 / 0.010 / 0.032	Vd/t - FF Reg-5 / 0.524 / 0.467 / 0.451	include           Reg-6           /           0.242           /           0.271           /           0.263	ed – Nine Reg-7 / 0.122 / 0.140 / 0.131	-zone pr Reg-8 / 0.050 / 0.058 / 0.053	orfile           Reg-9           /           0.041           /           0.046           /           0.045	CASE Reg-1 / 0.009 / 0.009 / 0.020	B' Bu Reg-2 / 0.011 / 0.012 / 0.024	rn-up = Reg-3 / 0.028 / 0.031 / 0.063	30 GWc Reg-4 / 0.070 / 0.070 / 0.144	//t - No ] Reg-5 / 0.763 / 0.662 / 0.687	FP includ Reg-6 / 0.071 / 0.121 / 0.036	ded – No Reg-7 / 0.029 / 0.055 / 0.015	ne-zone Reg-8 / 0.011 / 0.022 / 0.006	profile Reg-9 / 0.009 / 0.017 / 0.005
	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS	Country Sweden Germany UK Spain France Sweden Germany	CAS Reg-1 / 0.002 / 0.002 / 0.005 /	EB E Reg-2 / 0.002 / 0.002 / 0.005 /	Jurn-up :           Reg-3           /           0.005           /           0.005           /           0.005           /           0.016	= 30 GW Reg-4 / 0.011 / 0.010 / 0.032 /	Vd/t - FF Reg-5 / 0.524 / 0.467 / 0.451 /	include           Reg-6           /           0.242           /           0.271           /           0.263	cd – Nine Reg-7 / 0.122 / 0.140 / 0.131 /	-zone pr Reg-8 / 0.050 / 0.058 / 0.053 /	offile           Reg-9           /           0.041           /           0.046           /           0.045	CASE Reg-1 / 0.009 / 0.009 / 0.020 /	B' Bu Reg-2 / 0.011 / 0.012 / 0.024 /	rn-up =           Reg-3           /           0.028           /           0.031           /           0.063	30 GWc Reg-4 / 0.070 / 0.070 / 0.144 /	//t - No ] Reg-5 / 0.763 / 0.662 / 0.687 /	FP includ Reg-6 / 0.071 / 0.121 / 0.036 /	ded – No Reg-7 / 0.029 / 0.055 / 0.015 /	ne-zone Reg-8 / 0.011 / 0.022 / 0.006 /	oc/a           profile           Reg-9           /           0.009           /           0.017           /           0.005
# 1 2 3 4 5 6 7 8	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN	Country Sweden Germany UK Spain France Sweden Germany France	CAS Reg-1 / 0.002 / 0.002 / 0.005 / 0.038	<b>E B</b> E Reg-2 / 0.002 / 0.002 / 0.005 / 0.047	Jurn-up :           Reg-3           /           0.005           /           0.005           /           0.016           /           0.117	= 30 GW Reg-4 / 0.011 / 0.010 / 0.032 / 0.243	Vd/t - FF Reg-5 / 0.524 / 0.467 / 0.451 / 0.521	include           Reg-6           /           0.242           /           0.271           /           0.263           /           0.018	cd – Nine Reg-7 / 0.122 / 0.140 / 0.131 / 0.009	-zone pr Reg-8 / 0.050 / 0.058 / 0.053 / 0.004	ofile Reg-9 / 0.041 / 0.046 / 0.045 / 0.003	CASE Reg-1 / 0.009 / 0.009 / 0.020 / 0.004	B' Bu Reg-2 / 0.011 / 0.012 / 0.024 / 0.005	rm-up =           Reg-3           /           0.028           /           0.031           /           0.063           /           0.013	30 GWc Reg-4 / 0.070 / 0.070 / 0.144 / 0.029	//t - No 2 Reg-5 / 0.763 / 0.662 / 0.687 / 0.757	FP inclue Reg-6 / 0.071 / 0.121 / 0.036 / 0.117	ded – No Reg-7 / 0.029 / 0.055 / 0.015 / 0.046	ne-zone Reg-8 / 0.011 / 0.022 / 0.006 / 0.017	oor/a           profile           Reg-9           /           0.009           /           0.017           /           0.005           /           0.013
	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI	Country Sweden Germany UK Spain France Sweden Germany France Japan	CAS Reg-1 / 0.002 / 0.002 / 0.005 / 0.038 0.024	E B F Reg-2 / 0.002 / 0.002 / 0.005 / 0.047 0.029	Jurn-up :           Reg-3           /           0.005           /           0.005           /           0.016           /           0.1117           0.073	= 30 GW Reg-4 / 0.011 / 0.010 / 0.032 / 0.243 0.145	/d/t - FF Reg-5 / 0.524 / 0.467 / 0.467 / 0.451 / 0.521 0.598	Pinclude Reg-6 / 0.242 / 0.271 / 0.263 / 0.018 0.072	d - Nine Reg-7 / 0.122 / 0.140 / 0.131 / 0.009 0.034	-zone pr Reg-8 / 0.050 / 0.058 / 0.053 / 0.004 0.014	ofile Reg-9 / 0.041 / 0.046 / 0.045 / 0.003 0.011	CASE Reg-1 / 0.009 / 0.009 / 0.020 / 0.004 0.004	B' Bu Reg-2 / 0.011 / 0.012 / 0.024 / 0.005 0.012	m-up = Reg-3 / 0.028 / 0.031 / 0.063 / 0.013 0.031	30 GWc Reg-4 / 0.070 / 0.070 / 0.070 / 0.144 / 0.029 0.070	kit         No           Reg-5         /           0.763         /           0.662         /           0.6687         /           0.7577         0.731	FP inclue Reg-6 / 0.071 / 0.121 / 0.036 / 0.117 0.083	ded         No           Reg-7         /           0.029         /           0.055         /           0.015         /           0.046         0.037	Reg-8 / 0.011 / 0.022 / 0.006 / 0.017 0.014	oor/a           profile           Reg-9           /           0.009           /           0.017           /           0.005           /           0.013
$ \begin{array}{r} # \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan	CAS Reg-1 / 0.002 / 0.002 / 0.005 / 0.038 0.024 0.037	E B F Reg-2 / 0.002 / 0.002 / 0.005 / 0.047 0.029 0.046	Jurn-up           Burn-up           Reg-3           /           0.005           /           0.005           /           0.016           /           0.117           0.073	= 30 GW Reg-4 / 0.011 / 0.010 / 0.032 / 0.243 0.145 0.223	/d/t - FF Reg-5 / 0.524 / 0.467 / 0.451 / 0.521 0.598 0.505	Pinclude Reg-6 / 0.242 / 0.271 / 0.263 / 0.018 0.072 0.040	d - Nine Reg-7 / 0.122 / 0.140 / 0.131 / 0.009 0.034 0.021	-zone pr Reg-8 / 0.050 / 0.058 / 0.053 / 0.004 0.004 0.014 0.008	ofile Reg-9 / 0.041 / 0.046 / 0.045 / 0.003 0.011 0.007	CASE           Reg-1           /           0.009           /           0.009           /           0.009           /           0.009           /           0.009           /           0.009           /           0.004           0.009           0.010	B' Bu Reg-2 / 0.011 / 0.012 / 0.024 / 0.005 0.012 0.013	m-up = Reg-3 / 0.028 / 0.031 / 0.063 / 0.013 0.031 0.034	30 GWc Reg-4 / 0.070 / 0.070 / 0.070 / 0.144 / 0.029 0.070 0.079	/t - No ] Reg-5 / 0.763 / 0.662 / 0.687 / 0.757 0.731 0.730	FP inclue Reg-6 / 0.071 / 0.121 / 0.036 / 0.117 0.083 0.077	ded         No           Reg-7         /           0.029         /           0.055         /           0.015         /           0.015         /           0.046         0.037           0.034         -	Reg-8 / 0.011 / 0.022 / 0.006 / 0.017 0.014 0.013	orofile           profile           Reg-9           /           0.009           /           0.017           /           0.005           /           0.013           0.012
$ \begin{array}{r} # \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan	CAS Reg-1 / 0.002 / 0.002 / 0.005 / 0.038 0.024 0.037 0.032	E B F Reg-2 / 0.002 / 0.002 / 0.005 / 0.047 0.029 0.046 0.040	Jurn-up           Burn-up           Reg-3           /           0.005           /           0.005           /           0.016           /           0.117           0.073           0.113	= 30 GW Reg-4 / 0.011 / 0.010 / 0.032 / 0.243 0.145 0.223 0.194	Vd/t - FF Reg-5 / 0.524 / 0.467 / 0.451 / 0.521 0.598 0.505 0.480	Pinclude Reg-6 / 0.242 / 0.271 / 0.263 / 0.018 0.072 0.040 0.083	d - Nine Reg-7 / 0.122 / 0.140 / 0.131 / 0.009 0.034 0.021 0.042	-zone pr Reg-8 / 0.050 / 0.058 / 0.053 / 0.004 0.014 0.008 0.017	ofile Reg-9 / 0.041 / 0.046 / 0.045 / 0.003 0.011 0.007 0.014	CASE           Reg-1           /           0.009           /           0.009           /           0.009           /           0.009           /           0.009           /           0.004           0.009           0.010           0.016	B' Bu Reg-2 / 0.011 / 0.012 / 0.024 / 0.005 0.012 0.013 0.020	m-up = Reg-3 / 0.028 / 0.031 / 0.063 / 0.013 0.031 0.034 0.054	30 GWc Reg-4 / 0.070 / 0.070 / 0.070 / 0.144 / 0.029 0.070 0.079 0.126	/t - No           Reg-5           /           0.763           /           0.662           /           0.687           /           0.757           0.731           0.730           0.688	FP includ Reg-6 / 0.071 / 0.121 / 0.036 / 0.117 0.083 0.077 0.057	ded         No           Reg-7         /           0.029         /           0.055         /           0.015         /           0.015         /           0.046         0.037           0.034         0.023	Reg-8 / 0.011 / 0.022 / 0.006 / 0.017 0.014 0.013 0.009	profile           Reg-9           /           0.009           /           0.017           /           0.005           /           0.013           0.012           0.010
$ \begin{array}{r} # \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan Japan USA	CAS Reg-1 / 0.002 / 0.002 / 0.005 / 0.038 0.024 0.037 0.032 0.036	E B F Reg-2 / 0.002 / 0.002 / 0.005 / 0.005 / 0.047 0.029 0.046 0.040 0.043	Jurn-up           Burn-up           Reg-3           /           0.005           /           0.005           /           0.005           /           0.016           /           0.017           0.073           0.113           0.097           0.106	= 30 GW Reg-4 / 0.011 / 0.010 / 0.032 / 0.145 0.223 0.194 0.213	/d/t - FF Reg-5 / 0.524 / 0.467 / 0.451 / 0.521 0.598 0.505 0.480 0.524	Pinclude Reg-6 / 0.242 / 0.271 / 0.263 / 0.018 0.072 0.040 0.083 0.042	d - Nine Reg-7 / 0.122 / 0.140 / 0.131 / 0.009 0.034 0.021 0.042 0.021	-zone pr Reg-8 / 0.050 / 0.058 / 0.053 / 0.004 0.014 0.008 0.017 0.008	ofile Reg-9 / 0.041 / 0.046 / 0.045 / 0.003 0.011 0.007 0.014 0.007	CASE           Reg-1           /           0.009           /           0.009           /           0.009           /           0.009           /           0.009           /           0.009           /           0.004           0.009           0.010           0.016	B' Bu Reg-2 / 0.011 / 0.012 / 0.024 / 0.005 0.012 0.013 0.020 0.014	m-up = Reg-3 / 0.028 / 0.031 / 0.063 / 0.013 0.031 0.034 0.054 0.038	30 GWc Reg-4 / 0.070 / 0.070 / 0.070 / 0.029 0.070 0.079 0.126 0.086	//t - No           Reg-5           /           0.763           /           0.662           /           0.687           /           0.757           0.731           0.730           0.688           0.777	FP includ Reg-6 / 0.071 / 0.121 / 0.036 / 0.117 0.083 0.077 0.057 0.042	ded         No           Reg-7         /           0.029         /           0.055         /           0.015         /           0.015         /           0.046         0.037           0.034         0.023           0.018	Reg-8 / 0.011 / 0.022 / 0.006 / 0.017 0.014 0.013 0.009 0.007	op/o           profile           Reg-9           /           0.009           /           0.017           /           0.005           /           0.013           0.012           0.010           0.007
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\     12 \\     13 \\   \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL PNC	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan	CAS Reg-1 / 0.002 / 0.002 / 0.005 / 0.038 0.024 0.037 0.032 0.036 0.017	E B F Reg-2 / 0.002 / 0.002 / 0.005 / 0.047 0.047 0.047 0.047 0.047 0.047 0.044 0.040 0.044 0.043 0.022	Jurn-up           Burn-up           Reg-3           /           0.005           /           0.005           /           0.005           /           0.016           /           0.117           0.073           0.113           0.097           0.106           0.054	= 30 GW Reg-4 / 0.011 / 0.010 / 0.032 / 0.243 0.145 0.223 0.194 0.213 0.104	Vd/t - FF Reg-5 / 0.524 / 0.467 / 0.451 / 0.521 0.598 0.505 0.480 0.524 0.573	Pinclude Reg-6 / 0.242 / 0.271 / 0.263 / 0.018 0.072 0.040 0.083 0.042 0.122	d - Nine Reg-7 / 0.122 / 0.140 / 0.131 / 0.009 0.034 0.021 0.042 0.021 0.063	-zone pr Reg-8 / 0.050 / 0.058 / 0.053 / 0.004 0.014 0.008 0.017 0.008 0.025	ofile Reg-9 / 0.041 / 0.046 / 0.045 / 0.003 0.011 0.007 0.014 0.007 0.020	CASE Reg-1 / 0.009 / 0.009 / 0.000 / 0.004 0.009 0.010 0.016 0.011 0.009	B' Bu Reg-2 / 0.011 / 0.012 / 0.024 / 0.005 0.012 0.013 0.020 0.014 0.012	m-up = Reg-3 / 0.028 / 0.031 / 0.063 / 0.013 0.031 0.034 0.054 0.038 0.031	30 GWc Reg-4 / 0.070 / 0.070 / 0.070 / 0.044 / 0.029 0.070 0.079 0.126 0.086 0.072	//t - No           Reg-5           /           0.763           /           0.662           /           0.687           /           0.757           0.731           0.730           0.688           0.777           0.748	FP includ Reg-6 / 0.071 / 0.121 / 0.036 / 0.117 0.083 0.077 0.057 0.042 0.075	ded         No           Reg-7         /           0.029         /           0.055         /           0.015         /           0.015         /           0.046         0.037           0.034         0.023           0.018         0.032	Reg-8 / 0.011 / 0.022 / 0.006 / 0.017 0.014 0.013 0.009 0.007 0.012	op/o           profile           Reg-9           /           0.009           /           0.017           /           0.005           /           0.013           0.012           0.010           0.007           0.006           0.009
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\     12 \\     13 \\     14 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL PNC UKDOT	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan USA	CAS Reg-1 / 0.002 / 0.002 / 0.005 / 0.038 0.024 0.037 0.032 0.036 0.017 0.012	B         B         F           Reg-2         /         /           0.002         /         /           0.002         /         /           0.005         /         /           0.0047         0.029         0.046           0.040         0.043         0.022           0.014         0.014         0.022	Jurn-up           Burn-up           Reg-3           /           0.005           /           0.005           /           0.005           /           0.005           /           0.016           /           0.017           0.073           0.113           0.097           0.106           0.054           0.036	= 30 GW Reg-4 / 0.011 / 0.010 / 0.032 / 0.243 0.145 0.223 0.194 0.213 0.104 0.075	Vd/t - FF Reg-5 / 0.524 / 0.467 / 0.451 / 0.521 0.598 0.505 0.480 0.524 0.573 0.443	Pinclude Reg-6 / 0.242 / 0.271 / 0.263 / 0.0263 / 0.040 0.072 0.040 0.083 0.042 0.122 0.226	d - Nine Reg-7 / 0.122 / 0.140 / 0.131 / 0.009 0.034 0.021 0.042 0.021 0.063 0.112	-zone pr Reg-8 / 0.050 / 0.058 / 0.053 / 0.004 0.014 0.008 0.017 0.008 0.025 0.044	ofile Reg-9 / 0.041 / 0.046 / 0.045 / 0.003 0.011 0.007 0.014 0.007 0.020 0.038	CASE Reg-1 / 0.009 / 0.009 / 0.009 / 0.004 0.009 0.010 0.016 0.011 0.009 0.009	B' Bu Reg-2 / 0.011 / 0.012 / 0.024 / 0.005 0.012 0.013 0.020 0.014 0.012 0.011	m-up = Reg-3 / 0.028 / 0.031 / 0.063 / 0.013 0.031 0.034 0.034 0.034 0.038 0.031 0.030	30 GWc Reg-4 / 0.070 / 0.070 / 0.070 / 0.044 / 0.029 0.070 0.079 0.126 0.086 0.072 0.070	k         k           Reg-5         /           0.763         /           0.662         /           0.687         /           0.757         0.731           0.730         0.688           0.777         0.748           0.725         0.725	FP inclue Reg-6 / 0.071 / 0.121 / 0.036 / 0.117 0.083 0.077 0.057 0.042 0.075 0.089	ded         No           Reg-7         /           0.029         /           0.055         /           0.015         /           0.015         /           0.037         0.034           0.023         0.018           0.032         0.039	Reg-8 / 0.011 / 0.022 / 0.006 / 0.017 0.014 0.013 0.009 0.007 0.012 0.015	profile           Reg-9           /           0.009           /           0.017           /           0.005           /           0.013           0.012           0.010           0.007           0.006           0.009
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\     12 \\     13 \\     14 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL PNC UKDOT	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan USA Japan UK Average	CAS Reg-1 / 0.002 / 0.002 / 0.005 / 0.038 0.024 0.037 0.032 0.036 0.017 0.012 0.020	B         B         F           Reg-2         /         /           0.002         /         /           0.002         /         /           0.005         /         /           0.047         0.029         0.046           0.040         0.043         0.022           0.014         0.025         -	Jurn-up           Burn-up           Reg-3           /           0.005           /           0.005           /           0.005           /           0.005           /           0.016           /           0.117           0.073           0.113           0.097           0.106           0.054           0.036           0.062	= 30 GW Reg-4 / 0.011 / 0.010 / 0.032 / 0.243 0.145 0.223 0.194 0.213 0.104 0.075 0.125	//d/t - FF           Reg-5           /           0.524           /           0.467           /           0.451           /           0.521           0.598           0.505           0.480           0.524           0.505           0.480           0.524           0.505           0.480           0.524	Pinclude           Reg-6           /           0.242           /           0.271           /           0.263           /           0.018           0.072           0.040           0.083           0.042           0.122           0.226           0.138	d - Nine Reg-7 / 0.122 / 0.140 / 0.131 / 0.009 0.034 0.021 0.042 0.021 0.063 0.112 0.070	-zone pr Reg-8 / 0.050 / 0.058 / 0.053 / 0.004 0.014 0.008 0.017 0.008 0.025 0.044 0.028	ofile Reg-9 / 0.041 / 0.046 / 0.045 / 0.003 0.011 0.007 0.014 0.007 0.020 0.038 0.023	CASE           Reg-1           /           0.009           /           0.009           /           0.009           /           0.009           /           0.009           /           0.009           /           0.004           0.009           0.010           0.016           0.011           0.009           0.009           0.011	B' Bu Reg-2 / 0.011 / 0.012 / 0.024 / 0.005 0.012 0.013 0.020 0.014 0.012 0.011 0.012	m-up = Reg-3 / 0.028 / 0.031 / 0.063 / 0.013 0.031 0.034 0.034 0.034 0.034 0.034 0.033 0.031 0.030 0.030 0.035	30 GWc Reg-4 / 0.070 / 0.070 / 0.070 / 0.144 / 0.029 0.070 0.079 0.126 0.086 0.072 0.070 0.070 0.070	k         k           Reg-5         /           0.763         /           0.662         /           0.687         /           0.757         0.731           0.730         0.688           0.777         0.748           0.725         0.725	FP inclue Reg-6 / 0.071 / 0.121 / 0.036 / 0.117 0.083 0.077 0.057 0.042 0.075 0.089 0.077	ded         Ne           Reg-7         /           0.029         /           0.055         /           0.015         /           0.046         0.037           0.034         0.023           0.018         0.032           0.039         0.033	Reg-8 Reg-8 / 0.011 / 0.022 / 0.006 / 0.017 0.014 0.013 0.009 0.007 0.012 0.015 0.013	profile           Reg-9           /           0.009           /           0.017           /           0.005           /           0.013           0.012           0.010           0.007           0.006           0.009           0.012

			CA	SE C	Burn-u	0 = 50  G	Wd/t – I	FP inclue	ded – No	BU pro	file	CAS	E C' I	Burn-up	$= 50  \mathrm{GV}$	Vd/t - N	o FP inc	luded – I	No BU p	rofile
#	Institute	Country	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9
1	ABB	Sweden	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
2	BfS-IKE	Germany	0.001	0.002	0.006	0.020	0.926	0.028	0.010	0.004	0.003	0.001	0.002	0.004	0.016	0.902	0.051	0.016	0.005	0.004
3	BNFL	UK	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
4	CSN	Spain	0.002	0.003	0.008	0.025	0.925	0.025	0.008	0.003	0.002	0.002	0.003	0.008	0.025	0.925	0.025	0.008	0.003	0.002
5	CEA	France	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
6	EMS	Sweden	0.002	0.003	0.009	0.026	0.870	0.061	0.019	0.006	0.005	0.002	0.003	0.010	0.038	0.919	0.019	0.005	0.002	0.001
7	GRS	Germany	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
8	IPSN	France	0.000	0.000	0.001	0.005	0.970	0.017	0.004	0.001	0.001	0.000	0.001	0.003	0.010	0.904	0.057	0.016	0.005	0.004
9	JAERI	Japan	0.001	0.002	0.005	0.018	0.945	0.021	0.006	0.002	0.001	0.001	0.002	0.004	0.016	0.942	0.024	0.007	0.002	0.002
10	JINS-1	Japan	0.002	0.003	0.009	0.028	0.914	0.029	0.009	0.003	0.002	0.003	0.003	0.010	0.030	0.913	0.027	0.008	0.003	0.002
11	JINS-2	Japan	0.003	0.003	0.010	0.032	0.921	0.021	0.007	0.002	0.002	0.002	0.003	0.009	0.029	0.913	0.029	0.010	0.003	0.002
12	ORNL	USA	0.001	0.002	0.006	0.020	0.926	0.030	0.009	0.003	0.002	0.003	0.003	0.011	0.033	0.914	0.024	0.008	0.003	0.002
13	PNC	Japan	0.002	0.003	0.010	0.030	0.906	0.031	0.011	0.004	0.003	0.003	0.003	0.011	0.035	0.891	0.038	0.012	0.004	0.003
14	UKDOT	UK	0.002	0.003	0.008	0.031	0.918	0.026	0.008	0.003	0.002	0.002	0.002	0.008	0.027	0.930	0.021	0.006	0.002	0.002
		Average	0.002	0.002	0.007	0.023	0.922	0.029	0.009	0.003	0.002	0.002	0.002	0.008	0.026	0.915	0.032	0.010	0.003	0.002
		2 * o <sub>r</sub>	72%	67%	68%	64%	5%	76%	78%	76%	87%	75%	68%	69%	64%	3%	74%	75%	66%	67%
	L															0.10	, .			0.70
		•	CAS	ED H	Burn-up	= 50 GW	/d/t – FF	o include	ed – Nine	e-zone pi	rofile	CASE	<b>D'</b> Bu	ırn-up =	50 GW	d/t - No	FP inclu	ded – N	ine-zone	profile
#	Institute	Country	CAS Reg-1	ED H Reg-2	Burn-up Reg-3	= 50 GW Reg-4	/d/t – FF Reg-5	include Reg-6	d – Nine Reg-7	e-zone pi Reg-8	rofile Reg-9	CASE Reg-1	<b>D'</b> Bu Reg-2	ırn-up = Reg-3	50 GWo Reg-4	d/t – No Reg-5	FP inclu Reg-6	ded – N Reg-7	ine-zone Reg-8	profile Reg-9
# 1	Institute ABB	Country Sweden	CAS Reg-1 /	ED H Reg-2	Burn-up Reg-3	= 50 GW Reg-4 /	/d/t – FF Reg-5 /	P include Reg-6	ed – Nine Reg-7 /	e-zone pr Reg-8 /	rofile Reg-9 /	CASE Reg-1	D' Bu Reg-2 /	rn-up = Reg-3	50 GWc Reg-4 /	d/t – No Reg-5 /	FP inclu Reg-6	ded – N Reg-7 /	ine-zone Reg-8 /	profile Reg-9 /
# 1 2	Institute ABB BfS-IKE	Country Sweden Germany	CAS Reg-1 / 0.052	ED H Reg-2 / 0.061	Burn-up Reg-3 / 0.136	= 50 GW Reg-4 / 0.215	/d/t – FH Reg-5 / 0.273	• include Reg-6 / 0.127	ed – Nine Reg-7 / 0.076	e-zone pr Reg-8 / 0.033	rofile Reg-9 / 0.027	CASE Reg-1 / 0.022	D' Bu Reg-2 / 0.027	arn-up = Reg-3 / 0.066	50 GWa Reg-4 / 0.126	d/t - No Reg-5 / 0.478	FP inclu Reg-6 / 0.143	ded – N Reg-7 / 0.078	ine-zone Reg-8 / 0.033	profile Reg-9 / 0.028
# 1 2 3	Institute ABB BfS-IKE BNFL	Country Sweden Germany UK	CAS Reg-1 / 0.052 /	ED H Reg-2 / 0.061 /	Burn-up Reg-3 / 0.136 /	= 50 GW Reg-4 / 0.215 /	/d/t – FF Reg-5 / 0.273 /	P include Reg-6 / 0.127 /	ed – Nine Reg-7 / 0.076 /	e-zone pr Reg-8 / 0.033 /	rofile Reg-9 / 0.027 /	CASE Reg-1 / 0.022 /	D' Bu Reg-2 / 0.027 /	Irn-up = Reg-3 / 0.066 /	50 GWa Reg-4 / 0.126 /	d/t - No Reg-5 / 0.478 /	FP inclu Reg-6 / 0.143 /	ded – N Reg-7 / 0.078 /	Reg-8 / 0.033 /	profile Reg-9 / 0.028 /
# 1 2 3 4	Institute ABB BfS-IKE BNFL CSN	Country Sweden Germany UK Spain	CAS Reg-1 / 0.052 / 0.000	ED H Reg-2 / 0.061 / 0.000	3urn-up Reg-3 / 0.136 / 0.000	= 50 GW Reg-4 / 0.215 / 0.001	Vd/t - FF Reg-5 / 0.273 / 0.253	Pinclude Reg-6 / 0.127 / 0.339	ed – Nine Reg-7 / 0.076 / 0.221	e-zone pr Reg-8 / 0.033 / 0.102	rofile Reg-9 / 0.027 / 0.084	CASE Reg-1 / 0.022 / 0.001	D' Bu Reg-2 / 0.027 / 0.001	urn-up = Reg-3 / 0.066 / 0.002	50 GWa Reg-4 / 0.126 / 0.003	d/t - No Reg-5 / 0.478 / 0.392	FP inclu Reg-6 / 0.143 / 0.303	ded – N Reg-7 / 0.078 / 0.169	ine-zone Reg-8 / 0.033 / 0.073	profile Reg-9 / 0.028 / 0.058
# 1 2 3 4 5	Institute ABB BfS-IKE BNFL CSN CEA	Country Sweden Germany UK Spain France	CAS Reg-1 / 0.052 / 0.000 /	ED F Reg-2 / 0.061 / 0.000 /	Burn-up Reg-3 / 0.136 / 0.000 /	= 50 GW Reg-4 / 0.215 / 0.001 /	Vd/t - FF Reg-5 / 0.273 / 0.253 /	P include Reg-6 / 0.127 / 0.339 /	ed – Nine Reg-7 / 0.076 / 0.221 /	e-zone pr Reg-8 / 0.033 / 0.102 /	rofile Reg-9 / 0.027 / 0.084 /	CASE Reg-1 / 0.022 / 0.001 /	D' Bu Reg-2 / 0.027 / 0.001 /	Irn-up = Reg-3 / 0.066 / 0.002 /	50 GWa Reg-4 / 0.126 / 0.003 /	d/t - No Reg-5 / 0.478 / 0.392 /	FP inclu Reg-6 / 0.143 / 0.303 /	ded – N Reg-7 / 0.078 / 0.169 /	ine-zone Reg-8 / 0.033 / 0.073 /	profile Reg-9 / 0.028 / 0.058 /
# 1 2 3 4 5 6	Institute ABB BfS-IKE BNFL CSN CEA EMS	Country Sweden Germany UK Spain France Sweden	CAS Reg-1 / 0.052 / 0.000 / 0.055	ED F Reg-2 / 0.061 / 0.000 / 0.063	Burn-up Reg-3 / 0.136 / 0.000 / 0.141	= 50 GW Reg-4 / 0.215 / 0.001 / 0.219	Vd/t - FF Reg-5 / 0.273 / 0.253 / 0.224	<pre>Pinclude Reg-6     /     0.127     /     0.339     /     0.141</pre>	ed – Nine Reg-7 / 0.076 / 0.221 / 0.086	e-zone pr Reg-8 / 0.033 / 0.102 / 0.039	rofile Reg-9 / 0.027 / 0.084 / 0.031	CASE Reg-1 / 0.022 / 0.001 / 0.048	D' Bu Reg-2 / 0.027 / 0.001 / 0.058	irn-up = Reg-3 / 0.066 / 0.002 / 0.137	50 GWa Reg-4 / 0.126 / 0.003 / 0.264	d/t - No Reg-5 / 0.478 / 0.392 / 0.453	FP inclu Reg-6 / 0.143 / 0.303 / 0.021	ded – N Reg-7 / 0.078 / 0.169 / 0.011	ine-zone Reg-8 / 0.033 / 0.073 / 0.005	profile Reg-9 / 0.028 / 0.058 / 0.003
# 1 2 3 4 5 6 7	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS	Country Sweden Germany UK Spain France Sweden Germany	CAS Reg-1 / 0.052 / 0.000 / 0.055 /	ED H Reg-2 / 0.061 / 0.000 / 0.063 /	Burn-up Reg-3 / 0.136 / 0.000 / 0.141 /	= 50 GW Reg-4 / 0.215 / 0.001 / 0.219 /	Vd/t - FF Reg-5 / 0.273 / 0.253 / 0.224 /	<pre>&gt; include Reg-6 / 0.127 / 0.339 / 0.141 /</pre>	d – Nine Reg-7 / 0.076 / 0.221 / 0.086 /	e-zone pr Reg-8 / 0.033 / 0.102 / 0.039 /	rofile Reg-9 / 0.027 / 0.084 / 0.031 /	CASE Reg-1 / 0.022 / 0.001 / 0.048 /	D' Bu Reg-2 / 0.027 / 0.001 / 0.058 /	Irm-up = Reg-3 / 0.066 / 0.002 / 0.137 /	50 GWa Reg-4 / 0.126 / 0.003 / 0.264 /	d/t - No Reg-5 / 0.478 / 0.392 / 0.453 /	FP inclu Reg-6 / 0.143 / 0.303 / 0.021 /	ded – N Reg-7 / 0.078 / 0.169 / 0.011 /	ine-zone Reg-8 / 0.033 / 0.073 / 0.005 /	profile Reg-9 / 0.028 / 0.058 / 0.003 /
# 1 2 3 4 5 6 7 8	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN	Country Sweden Germany UK Spain France Sweden Germany France	CAS Reg-1 / 0.052 / 0.000 / 0.055 / 0.081	E D H Reg-2 / 0.061 / 0.000 / 0.063 / 0.095	Burn-up Reg-3 / 0.136 / 0.000 / 0.141 / 0.214	= 50 GW Reg-4 / 0.215 / 0.001 / 0.219 / 0.336	Vd/t - FF Reg-5 / 0.273 / 0.253 / 0.224 / 0.224 / 0.254	<pre>'include Reg-6 / 0.127 / 0.339 / 0.141 / 0.009</pre>	d – Nine Reg-7 / 0.076 / 0.221 / 0.086 / 0.007	e-zone pr Reg-8 / 0.033 / 0.102 / 0.039 / 0.003	rofile Reg-9 / 0.027 / 0.084 / 0.031 / 0.002	CASE Reg-1 / 0.022 / 0.001 / 0.048 / 0.032	D' Bu Reg-2 / 0.027 / 0.001 / 0.058 / 0.041	Irm-up = Reg-3 / 0.066 / 0.002 / 0.137 / 0.102	50 GWa Reg-4 / 0.126 / 0.003 / 0.264 / 0.190	d/t - No Reg-5 / 0.478 / 0.392 / 0.453 / 0.439	FP inclu Reg-6 / 0.143 / 0.303 / 0.021 / 0.101	ded – N Reg-7 / 0.078 / 0.169 / 0.011 / 0.055	ine-zone Reg-8 / 0.033 / 0.073 / 0.005 / 0.005 / 0.022	profile Reg-9 / 0.028 / 0.058 / 0.003 / 0.017
# 1 2 3 4 5 6 7 8 9	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI	Country Sweden Germany UK Spain France Sweden Germany France Japan	CAS Reg-1 / 0.052 / 0.000 / 0.055 / 0.081 0.053	E D H Reg-2 / 0.061 / 0.000 / 0.063 / 0.095 0.063	Burn-up Reg-3 / 0.136 / 0.000 / 0.141 / 0.214 0.139	= 50 GW Reg-4 / 0.215 / 0.001 / 0.219 / 0.336 0.216	/d/t - FF Reg-5 / 0.273 / 0.253 / 0.224 / 0.224 / 0.254 0.263	<pre>include Reg-6 / 0.127 / 0.339 / 0.141 / 0.009 0.121</pre>	d – Nind Reg-7 / 0.076 / 0.221 / 0.086 / 0.007 0.079	-zone pr Reg-8 / 0.033 / 0.102 / 0.039 / 0.003 0.036	rofile Reg-9 / 0.027 / 0.084 / 0.031 / 0.002 0.031	CASE Reg-1 / 0.022 / 0.001 / 0.048 / 0.032 0.015	D' Bu Reg-2 / 0.027 / 0.001 / 0.058 / 0.041 0.018	Irm-up = Reg-3 / 0.066 / 0.002 / 0.137 / 0.102 0.044	50 GWa Reg-4 / 0.126 / 0.003 / 0.264 / 0.190 0.082	d/t - No Reg-5 / 0.478 / 0.392 / 0.453 / 0.439 0.426	FP inclu Reg-6 / 0.143 / 0.303 / 0.021 / 0.101 0.212	ded – N Reg-7 / 0.078 / 0.169 / 0.011 / 0.055 0.115	ine-zone Reg-8 / 0.033 / 0.073 / 0.005 / 0.022 0.048	profile Reg-9 / 0.028 / 0.058 / 0.003 / 0.017 0.040
# 1 2 3 4 5 6 7 8 9 10	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan	CAS Reg-1 / 0.052 / 0.000 / 0.055 / 0.081 0.053 0.041	E D H Reg-2 / 0.061 / 0.000 / 0.063 / 0.095 0.063 0.048	Burn-up Reg-3 / 0.136 / 0.000 / 0.141 / 0.214 0.139 0.109	= 50 GW Reg-4 / 0.215 / 0.001 / 0.219 / 0.336 0.216 0.174	/d/t - FF Reg-5 / 0.273 / 0.253 / 0.224 / 0.224 / 0.224 / 0.254 0.263 0.285	rinclude Reg-6 / 0.127 / 0.339 / 0.141 / 0.009 0.121 0.161	d - Nine Reg-7 / 0.076 / 0.221 / 0.086 / 0.007 0.007 0.100	-zone pr Reg-8 / 0.033 / 0.102 / 0.039 / 0.003 0.036 0.044	rofile Reg-9 / 0.027 / 0.084 / 0.031 / 0.002 0.031 0.037	CASE Reg-1 / 0.022 / 0.001 / 0.048 / 0.048 / 0.032 0.015 0.018	D' Bu Reg-2 / 0.027 / 0.001 / 0.058 / 0.058 / 0.041 0.018 0.021	Irm-up = Reg-3 / 0.066 / 0.002 / 0.137 / 0.102 0.044 0.052	50 GWa Reg-4 / 0.126 / 0.003 / 0.264 / 0.190 0.082 0.099	d/t - No Reg-5 / 0.478 / 0.392 / 0.453 / 0.453 / 0.439 0.426 0.471	FP inclu Reg-6 / 0.143 / 0.303 / 0.021 / 0.101 0.212 0.177	ded – N Reg-7 / 0.078 / 0.169 / 0.011 / 0.055 0.115 0.091	ine-zone Reg-8 / 0.033 / 0.073 / 0.005 / 0.005 / 0.022 0.048 0.039	profile Reg-9 / 0.028 / 0.058 / 0.003 / 0.017 0.040 0.032
# 1 2 3 4 5 6 7 8 9 10 11	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS GRS IPSN JAERI JINS-1 JINS-2	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan	CAS Reg-1 / 0.052 / 0.000 / 0.055 / 0.081 0.053 0.041 0.036	E D H Reg-2 / 0.061 / 0.000 / 0.063 / 0.095 0.063 0.048 0.041	Burn-up Reg-3 / 0.136 / 0.000 / 0.141 / 0.214 0.139 0.109 0.093	= 50 GW Reg-4 / 0.215 / 0.001 / 0.219 / 0.336 0.216 0.174 0.150	/d/t - FH Reg-5 / 0.273 / 0.253 / 0.224 / 0.224 / 0.254 0.263 0.285 0.292	rinclude Reg-6 / 0.127 / 0.339 / 0.141 / 0.009 0.121 0.161 0.183	d - Nine Reg-7 / 0.076 / 0.221 / 0.086 / 0.007 0.007 0.007 0.100 0.112	-zone pr Reg-8 / 0.033 / 0.102 / 0.039 / 0.003 0.036 0.044 0.050	rofile Reg-9 / 0.027 / 0.084 / 0.031 / 0.002 0.031 0.037 0.043	CASE Reg-1 / 0.022 / 0.001 / 0.048 / 0.032 0.015 0.018 0.018	D' Bu Reg-2 / 0.027 / 0.001 / 0.058 / 0.041 0.018 0.021 0.022	Irm-up = Reg-3 / 0.066 / 0.002 / 0.137 / 0.102 0.044 0.052 0.051	50 GWa Reg-4 / 0.126 / 0.003 / 0.264 / 0.264 / 0.190 0.082 0.099 0.095	d/t - No Reg-5 / 0.478 / 0.392 / 0.453 / 0.453 / 0.439 0.426 0.471 0.464	FP inclu Reg-6 / 0.143 / 0.303 / 0.021 / 0.101 0.212 0.177 0.186	ded – N Reg-7 / 0.078 / 0.0169 / 0.011 / 0.055 0.115 0.091 0.094	ine-zone Reg-8 / 0.033 / 0.073 / 0.005 / 0.005 / 0.022 0.048 0.039 0.038	profile Reg-9 / 0.028 / 0.058 / 0.003 / 0.003 / 0.017 0.040 0.032 0.032
	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS GRS IPSN JAERI JINS-1 JINS-2 ORNL	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA	CAS Reg-1 / 0.052 / 0.000 / 0.055 / 0.081 0.053 0.041 0.036 0.016	E D H Reg-2 / 0.061 / 0.000 / 0.063 / 0.095 0.063 0.048 0.041 0.020	Burn-up Reg-3 / 0.136 / 0.000 / 0.141 / 0.214 0.139 0.109 0.093 0.045	= 50 GW Reg-4 / 0.215 / 0.001 / 0.219 / 0.336 0.216 0.174 0.150 0.073	/d/t - FH Reg-5 / 0.273 / 0.253 / 0.224 / 0.224 / 0.254 0.263 0.285 0.292 0.292	rinclude Reg-6 / 0.127 / 0.339 / 0.141 / 0.009 0.121 0.161 0.183 0.261	d - Nine Reg-7 / 0.076 / 0.221 / 0.086 / 0.007 0.007 0.007 0.100 0.112 0.165	-zone pr Reg-8 / 0.033 / 0.102 / 0.039 / 0.003 0.036 0.044 0.050 0.075 2.615	rofile Reg-9 / 0.027 / 0.084 / 0.031 / 0.002 0.031 0.037 0.043 0.065	CASE Reg-1 / 0.022 / 0.001 / 0.048 / 0.048 / 0.015 0.015 0.018 0.018 0.016	D' Bu Reg-2 / 0.027 / 0.001 / 0.001 / 0.058 / 0.041 0.018 0.021 0.022 0.019	Irm-up = Reg-3 / 0.066 / 0.002 / 0.102 0.044 0.052 0.045 0.045 0.045	50 GWa Reg-4 / 0.126 / 0.003 / 0.264 / 0.264 / 0.190 0.082 0.099 0.095 0.082	d/t - No Reg-5 / 0.478 / 0.392 / 0.453 / 0.453 / 0.426 0.426 0.471 0.464 0.431	FP inclu Reg-6 / 0.143 / 0.303 / 0.021 / 0.101 0.212 0.177 0.186 0.209	ded – N Reg-7 / 0.078 / 0.0169 / 0.011 / 0.055 0.115 0.091 0.094 0.111	ine-zone Reg-8 / 0.033 / 0.073 / 0.005 / 0.005 / 0.022 0.048 0.039 0.038 0.047	profile Reg-9 / 0.028 / 0.058 / 0.003 / 0.017 0.040 0.032 0.032 0.032
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\     12 \\     13 \\     13 \\   \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL PNC	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan	CAS Reg-1 / 0.052 / 0.000 / 0.055 / 0.081 0.053 0.041 0.036 0.016 0.040	E D H Reg-2 / 0.061 / 0.000 / 0.063 / 0.063 0.048 0.041 0.020 0.048	Burn-up Reg-3 / 0.136 / 0.000 / 0.141 / 0.141 / 0.141 0.139 0.109 0.093 0.045 0.106	= 50 GW Reg-4 / 0.215 / 0.001 / 0.219 / 0.336 0.216 0.174 0.150 0.073 0.173	/d/t - FH Reg-5 / 0.273 / 0.253 / 0.253 / 0.224 / 0.254 0.263 0.285 0.292 0.280 0.385	rinclude Reg-6 / 0.127 / 0.339 / 0.141 / 0.009 0.121 0.161 0.183 0.261 0.147	d - Nine Reg-7 / 0.076 / 0.221 / 0.086 / 0.007 0.007 0.007 0.100 0.112 0.165 0.093 0.45	-zone pr Reg-8 / 0.033 / 0.102 / 0.039 / 0.003 0.036 0.044 0.050 0.075 0.042 0.022	rofile Reg-9 / 0.027 / 0.084 / 0.031 / 0.002 0.031 0.037 0.043 0.043 0.065 0.035	CASE Reg-1 / 0.022 / 0.001 / 0.048 / 0.032 0.015 0.018 0.018 0.016 0.021	D' Bu Reg-2 / 0.027 / 0.001 / 0.001 / 0.058 / 0.041 0.021 0.022 0.019 0.024	Irn-up = Reg-3 / 0.066 / 0.002 / 0.102 0.044 0.052 0.045 0.063 0.063	50 GWa Reg-4 / 0.126 / 0.003 / 0.264 / 0.264 / 0.190 0.082 0.099 0.095 0.082 0.082	d/t - No Reg-5 / 0.478 / 0.392 / 0.453 / 0.453 / 0.426 0.471 0.426 0.471 0.464 0.431 0.525	FP inclu Reg-6 / 0.143 / 0.303 / 0.021 / 0.101 0.212 0.177 0.186 0.209 0.131	ded – N Reg-7 / 0.078 / 0.0169 / 0.011 / 0.055 0.115 0.091 0.094 0.111 0.065	ine-zone Reg-8 / 0.033 / 0.073 / 0.005 / 0.005 / 0.022 0.048 0.039 0.038 0.047 0.026	profile Reg-9 / 0.028 / 0.058 / 0.003 / 0.003 / 0.017 0.040 0.032 0.032 0.032 0.039 0.022
$ \begin{array}{r} \# \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-1 JINS-2 ORNL PNC UKDOT	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan USA Japan UK	CAS Reg-1 / 0.052 / 0.000 / 0.055 / 0.081 0.053 0.041 0.036 0.041 0.036 0.016 0.040	E D H Reg-2 / 0.061 / 0.000 / 0.063 / 0.043 0.048 0.041 0.020 0.048 0.024	Burn-up Reg-3 / 0.136 / 0.000 / 0.141 / 0.141 / 0.214 0.139 0.109 0.093 0.045 0.106 0.053	= 50 GW Reg-4 / 0.215 / 0.001 / 0.219 / 0.336 0.216 0.174 0.150 0.073 0.173 0.082	/d/t - FH Reg-5 / 0.273 / 0.253 / 0.253 / 0.224 / 0.254 0.263 0.285 0.292 0.280 0.316 0.253	rinclude Reg-6 / 0.127 / 0.339 / 0.141 / 0.009 0.121 0.161 0.183 0.261 0.147 0.257	d - Nine Reg-7 / 0.076 / 0.221 / 0.086 / 0.007 0.007 0.007 0.100 0.112 0.165 0.093 0.167	-zone pr Reg-8 / 0.033 / 0.102 / 0.039 / 0.003 0.036 0.044 0.050 0.075 0.042 0.077	rofile Reg-9 / 0.027 / 0.084 / 0.031 / 0.002 0.031 0.037 0.043 0.065 0.035 0.035	CASE Reg-1 / 0.022 / 0.001 / 0.048 / 0.032 0.015 0.018 0.018 0.018 0.016 0.021 0.021	D' Bu Reg-2 / 0.027 / 0.001 / 0.001 / 0.058 / 0.041 0.022 0.018 0.022 0.019 0.026 0.015	ITT-up = Reg-3 / 0.066 / 0.002 / 0.137 / 0.102 0.044 0.052 0.045 0.063 0.037	50 GWa Reg-4 / 0.126 / 0.003 / 0.264 / 0.190 0.082 0.099 0.095 0.082 0.121 0.070	d/t - No           Reg-5           /           0.478           /           0.392           /           0.453           /           0.453           /           0.426           0.426           0.426           0.426           0.426           0.426           0.431           0.525           0.434	FP inclu Reg-6 / 0.143 / 0.303 / 0.021 / 0.101 0.212 0.177 0.186 0.209 0.131 0.219	ded – N Reg-7 / 0.078 / 0.0169 / 0.011 / 0.055 0.115 0.091 0.094 0.111 0.065 0.121	ine-zone Reg-8 / 0.033 / 0.073 / 0.005 / 0.022 0.048 0.039 0.038 0.047 0.026 0.050	profile Reg-9 / 0.028 / 0.058 / 0.003 / 0.003 / 0.017 0.040 0.032 0.032 0.032 0.032 0.039 0.022 0.041
$ \begin{array}{c}     # \\     1 \\     2 \\     3 \\     4 \\     5 \\     6 \\     7 \\     8 \\     9 \\     10 \\     11 \\     12 \\     13 \\     14 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL PNC UKDOT	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan USA Japan UK Average	CAS Reg-1 / 0.052 / 0.000 / 0.055 / 0.081 0.053 0.041 0.036 0.016 0.040 0.020 0.020	E D H Reg-2 / 0.061 / 0.000 / 0.063 / 0.043 0.041 0.020 0.048 0.024 0.024 0.024	Burn-up Reg-3 / 0.136 / 0.000 / 0.141 / 0.141 / 0.214 0.139 0.109 0.093 0.045 0.106 0.053 0.104	= 50 GW Reg-4 / 0.215 / 0.001 / 0.219 / 0.219 / 0.336 0.216 0.174 0.150 0.073 0.173 0.082 0.164	/d/t - FH Reg-5 / 0.273 / 0.253 / 0.224 / 0.254 0.263 0.285 0.292 0.280 0.280 0.280 0.216 0.253 0.269	rinclude Reg-6 / 0.127 / 0.339 / 0.141 / 0.009 0.121 0.161 0.183 0.261 0.147 0.257 0.175	d - Nind Reg-7 / 0.076 / 0.221 / 0.086 / 0.007 0.007 0.007 0.007 0.100 0.112 0.165 0.093 0.167 0.111	-zone pr Reg-8 / 0.033 / 0.102 / 0.039 / 0.003 0.036 0.044 0.050 0.075 0.042 0.077 0.050	rofile Reg-9 / 0.027 / 0.084 / 0.031 / 0.002 0.031 0.037 0.043 0.065 0.035 0.065 0.042	CASE Reg-1 / 0.022 / 0.001 / 0.048 / 0.032 0.015 0.018 0.016 0.021 0.020 0.020	D' Bu Reg-2 / 0.027 / 0.001 / 0.001 / 0.058 / 0.041 0.021 0.022 0.019 0.026 0.015 0.025	Im-up = Reg-3 / 0.066 / 0.002 / 0.137 / 0.102 0.044 0.052 0.045 0.063 0.037 0.060	50 GWa Reg-4 / 0.126 / 0.003 / 0.264 / 0.190 0.082 0.099 0.095 0.082 0.121 0.070 0.113	d/t - No           Reg-5           /           0.478           /           0.392           /           0.453           /           0.453           /           0.453           /           0.426           0.471           0.464           0.431           0.525           0.434           0.451	FP inclu Reg-6 / 0.143 / 0.303 / 0.021 / 0.101 0.212 0.177 0.186 0.209 0.131 0.219 0.170	ded – N Reg-7 / 0.078 / 0.0169 / 0.011 / 0.055 0.115 0.091 0.094 0.111 0.065 0.121 0.091	ine-zone Reg-8 / 0.033 / 0.073 / 0.005 / 0.022 0.048 0.039 0.038 0.047 0.026 0.050 0.038	profile Reg-9 / 0.028 / 0.058 / 0.003 / 0.003 / 0.040 0.032 0.032 0.032 0.032 0.032 0.022 0.021

## Table 9. Normalised fission fractions (cont.)

					CASE	E					
					Fresh f	uel					
#	Institute	Country	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9
1	ABB	Sweden	/	/	/	/	/	/	/	/	/
2	BfS-IKE	Germany	0.002	0.003	0.010	0.031	0.901	0.035	0.011	0.004	0.003
3	BNFL	UK	/	/	/	/	/	/	/	/	/
4	CSN	Spain	0.002	0.003	0.008	0.025	0.925	0.025	0.008	0.003	0.002
5	CEA	France	/	/	/	/	/	/	/	/	/
6	EMS	Sweden	0.004	0.005	0.014	0.043	0.888	0.031	0.010	0.004	0.002
7	GRS	Germany	/	/	/	/	/	/	/	/	/
8	IPSN	France	0.001	0.002	0.006	0.024	0.935	0.022	0.006	0.002	0.001
9	JAERI	Japan	0.001	0.002	0.005	0.018	0.948	0.019	0.006	0.002	0.001
10	JINS-1	Japan	0.002	0.003	0.008	0.026	0.923	0.025	0.008	0.003	0.002
11	JINS-2	Japan	0.002	0.002	0.007	0.022	0.925	0.027	0.009	0.003	0.002
12	ORNL	USA	0.002	0.003	0.008	0.025	0.891	0.046	0.015	0.005	0.004
13	PNC	Japan	0.002	0.003	0.008	0.026	0.909	0.035	0.011	0.004	0.002
14	UKDOT	UK	0.002	0.003	0.008	0.025	0.928	0.023	0.008	0.003	0.002
		Average	0.002	0.003	0.008	0.027	0.917	0.029	0.009	0.003	0.002
		2 * <b>o</b> r	62%	57%	57%	45%	4%	51%	56%	61%	66%

 Table 9. Normalised fission fractions (cont.)

### Table 10. Normalised fission densities

			CA	SE A	Burn-uj	p = 30 G	Wd/t – I	FP inclue	ded – No	BU pro	file	CAS	EA'I	Burn-up	$= 30  \mathrm{GV}$	Vd/t – N	o FP incl	luded – I	No BU p	orofile
#	Institute	Country	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9
1	ABB	Sweden	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
2	BfS-IKE	Germany	0.065	0.079	0.112	0.165	0.274	0.124	0.088	0.052	0.041	0.018	0.039	0.038	0.069	0.391	0.195	0.111	0.077	0.061
3	BNFL	UK	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
4	CSN	Spain	0.040	0.057	0.084	0.138	0.354	0.139	0.086	0.058	0.043	0.040	0.056	0.084	0.138	0.353	0.139	0.090	0.058	0.042
5	CEA	France	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
6	EMS	Sweden	0.049	0.059	0.088	0.137	0.275	0.147	0.108	0.078	0.059	0.051	0.061	0.091	0.152	0.273	0.152	0.101	0.071	0.051
7	GRS	Germany	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
8	IPSN	France	0.013	0.020	0.029	0.056	0.389	0.233	0.128	0.081	0.051	0.031	0.043	0.069	0.156	0.435	0.114	0.080	0.041	0.031
9	JAERI	Japan	0.041	0.060	0.084	0.124	0.361	0.138	0.085	0.062	0.045	0.037	0.051	0.079	0.136	0.483	0.099	0.057	0.034	0.023
10	JINS-1	Japan	0.036	0.045	0.066	0.099	0.279	0.202	0.123	0.086	0.065	0.049	0.067	0.100	0.162	0.315	0.132	0.082	0.055	0.039
11	JINS-2	Japan	0.050	0.066	0.102	0.157	0.332	0.126	0.076	0.052	0.038	0.045	0.060	0.084	0.140	0.336	0.136	0.088	0.062	0.049
12	ORNL	USA	0.059	0.072	0.112	0.182	0.352	0.092	0.057	0.041	0.032	0.056	0.078	0.118	0.187	0.352	0.090	0.055	0.039	0.025
13	PNC	Japan	0.056	0.075	0.103	0.159	0.296	0.135	0.084	0.056	0.037	0.039	0.059	0.089	0.133	0.314	0.168	0.099	0.059	0.039
14	UKDOT	UK	0.012	0.015	0.023	0.038	0.340	0.243	0.149	0.099	0.081	0.048	0.062	0.091	0.150	0.365	0.124	0.076	0.049	0.035
		Average	0.042	0.055	0.080	0.126	0.325	0.158	0.098	0.067	0.049	0.041	0.058	0.084	0.142	0.362	0.135	0.084	0.055	0.039
		2 * o <sub>r</sub>	78%	72%	72%	68%	23%	57%	51%	50%	55%	47%	35%	44%	38%	31%	42%	39%	46%	54%
										/ -				, .	/ -					/ -
	L	•	CAS	EB E	Burn-up	= 30 GW	Vd/t - FF	o include	ed – Nine	-zone pi	ofile	CASE	<b>B'</b> Bi	ırn-up =	30 GW	₫/t – No	FP inclu	ded – Ni	ne-zone	profile
#	Institute	Country	CAS Reg-1	<b>E B</b> E Reg-2	Burn-up Reg-3	= 30 GW Reg-4	/d/t – FI Reg-5	include Reg-6	d – Nine Reg-7	-zone pi Reg-8	ofile Reg-9	CASE Reg-1	<b>B'</b> Bu Reg-2	ırn-up = Reg-3	30 GWo Reg-4	d/t – No Reg-5	FP inclu Reg-6	ded – Ni Reg-7	ne-zone Reg-8	profile Reg-9
# 1	Institute ABB	Country Sweden	CAS Reg-1 /	EB Reg-2	Burn-up Reg-3	= 30 GW Reg-4 /	/d/t – FI Reg-5 /	include Reg-6	ed – Nine Reg-7 /	e-zone pi Reg-8 /	rofile Reg-9 /	CASE Reg-1	<b>B'</b> Bu Reg-2	arn-up = Reg-3	30 GWc Reg-4 /	d/t – No Reg-5 /	FP inclu Reg-6	ded – Ni Reg-7 /	ine-zone Reg-8	profile Reg-9 /
# 1 2	Institute ABB BfS-IKE	Country Sweden Germany	CAS Reg-1 / 0.008	E B H Reg-2 / 0.009	Burn-up Reg-3 / 0.011	= 30 GW Reg-4 / 0.012	Vd/t – FI Reg-5 / 0.040	• include Reg-6 / 0.262	d – Nine Reg-7 / 0.265	e-zone pi Reg-8 / 0.217	rofile Reg-9 / 0.177	CASE Reg-1 / 0.074	B' Bu Reg-2 / 0.091	rn-up = Reg-3 / 0.122	30 GWa Reg-4 / 0.149	d/t – No Reg-5 / 0.115	FP inclu Reg-6 / 0.152	ded – N Reg-7 / 0.125	ine-zone Reg-8 / 0.097	profile Reg-9 / 0.076
# 1 2 3	Institute ABB BfS-IKE BNFL	Country Sweden Germany UK	CAS Reg-1 / 0.008 /	E B E Reg-2 / 0.009 /	Burn-up Reg-3 / 0.011 /	= 30 GW Reg-4 / 0.012 /	Vd/t – FF Reg-5 / 0.040 /	P include Reg-6 / 0.262 /	d – Nine Reg-7 / 0.265 /	e-zone pr Reg-8 / 0.217 /	rofile Reg-9 / 0.177 /	CASE Reg-1 / 0.074 /	B' Bu Reg-2 / 0.091 /	nrn-up = Reg-3 / 0.122 /	30 GWa Reg-4 / 0.149 /	d/t - No Reg-5 / 0.115 /	FP inclu Reg-6 / 0.152 /	ded – Ni Reg-7 / 0.125 /	ine-zone Reg-8 / 0.097 /	profile Reg-9 / 0.076 /
# 1 2 3 4	Institute ABB BfS-IKE BNFL CSN	Country Sweden Germany UK Spain	CAS Reg-1 / 0.008 / 0.006	EB B Reg-2 / 0.009 / 0.008	Burn-up Reg-3 / 0.011 / 0.010	= 30 GW Reg-4 / 0.012 / 0.010	Vd/t - FI Reg-5 / 0.040 / 0.032	<pre>'include Reg-6 / 0.262 / 0.262</pre>	d – Nine Reg-7 / 0.265 / 0.270	-zone pr Reg-8 / 0.217 / 0.225	rofile Reg-9 / 0.177 / 0.178	CASE Reg-1 / 0.074 / 0.057	B' Bu Reg-2 / 0.091 / 0.076	nrn-up = Reg-3 / 0.122 / 0.096	30 GWa Reg-4 / 0.149 / 0.107	d/t - No Reg-5 / 0.115 / 0.071	FP inclu Reg-6 / 0.152 / 0.186	ded – N Reg-7 / 0.125 / 0.169	ine-zone Reg-8 / 0.097 / 0.134	profile Reg-9 / 0.076 / 0.104
# 1 2 3 4 5	Institute ABB BfS-IKE BNFL CSN CEA	Country Sweden Germany UK Spain France	CAS Reg-1 / 0.008 / 0.006 /	EB P Reg-2 / 0.009 / 0.008 /	Burn-up = Reg-3 / 0.011 / 0.010 /	= 30 GW Reg-4 / 0.012 / 0.010 /	Vd/t - FI Reg-5 / 0.040 / 0.032 /	<pre>'include Reg-6 / 0.262 / 0.262 /</pre>	rd – Nine Reg-7 / 0.265 / 0.270 /	-zone pr Reg-8 / 0.217 / 0.225 /	rofile Reg-9 / 0.177 / 0.178 /	CASE Reg-1 / 0.074 / 0.057 /	B' Bu Reg-2 / 0.091 / 0.076 /	urn-up = Reg-3 / 0.122 / 0.096 /	30 GWc Reg-4 / 0.149 / 0.107 /	d/t - No Reg-5 / 0.115 / 0.071 /	FP inclu Reg-6 / 0.152 / 0.186 /	ded – Ni Reg-7 / 0.125 / 0.169 /	ine-zone Reg-8 / 0.097 / 0.134 /	profile Reg-9 / 0.076 / 0.104 /
$ $	Institute ABB BfS-IKE BNFL CSN CEA EMS	Country Sweden Germany UK Spain France Sweden	CAS Reg-1 / 0.008 / 0.006 / 0.020	EB F Reg-2 / 0.009 / 0.008 / 0.020	Burn-up Reg-3 / 0.011 / 0.010 / 0.030	= 30 GW Reg-4 / 0.012 / 0.010 / 0.030	Vd/t - FF Reg-5 / 0.040 / 0.032 / 0.030	<pre>'include Reg-6 / 0.262 / 0.262 / 0.250</pre>	d – Nine Reg-7 / 0.265 / 0.270 / 0.250	-zone pr Reg-8 / 0.217 / 0.225 / 0.200	rofile Reg-9 / 0.177 / 0.178 / 0.170	CASE Reg-1 / 0.074 / 0.057 / 0.130	B' Bu Reg-2 / 0.091 / 0.076 / 0.160	irn-up = Reg-3 / 0.122 / 0.096 / 0.210	30 GWa Reg-4 / 0.149 / 0.107 / 0.240	d/t - No Reg-5 / 0.115 / 0.071 / 0.080	FP inclu Reg-6 / 0.152 / 0.186 / 0.060	ded – N Reg-7 / 0.125 / 0.169 / 0.050	ine-zone Reg-8 / 0.097 / 0.134 / 0.040	profile Reg-9 / 0.076 / 0.104 / 0.030
# 1 2 3 4 5 6 7	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS	Country Sweden Germany UK Spain France Sweden Germany	CAS Reg-1 / 0.008 / 0.006 / 0.020 /	EB F Reg-2 / 0.009 / 0.008 / 0.020 /	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 /	= 30 GW Reg-4 / 0.012 / 0.010 / 0.030 /	Vd/t - FF Reg-5 / 0.040 / 0.032 / 0.030 /	<pre>'include Reg-6 / 0.262 / 0.262 / 0.250 /</pre>	d – Nine Reg-7 / 0.265 / 0.270 / 0.250 /	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 /	rofile Reg-9 / 0.177 / 0.178 / 0.170 /	CASE Reg-1 / 0.074 / 0.057 / 0.130 /	B' Bu Reg-2 / 0.091 / 0.076 / 0.160 /	irn-up = Reg-3 / 0.122 / 0.096 / 0.210 /	30 GWa Reg-4 / 0.149 / 0.107 / 0.240 /	d/t - No Reg-5 / 0.115 / 0.071 / 0.080 /	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 /	ded – N Reg-7 / 0.125 / 0.169 / 0.050 /	ine-zone Reg-8 / 0.097 / 0.134 / 0.040 /	profile Reg-9 / 0.076 / 0.104 / 0.030 /
	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN	Country Sweden Germany UK Spain France Sweden Germany France	CAS Reg-1 / 0.008 / 0.006 / 0.020 / 0.167	EB F Reg-2 / 0.009 / 0.008 / 0.020 / 0.203	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.255	= 30 GW Reg-4 / 0.012 / 0.010 / 0.030 / 0.264	Vd/t - FF Reg-5 / 0.040 / 0.032 / 0.030 / 0.040	<pre>'include Reg-6 / 0.262 / 0.262 / 0.250 / 0.019</pre>	d – Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.020	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.017	ofile Reg-9 / 0.177 / 0.178 / 0.170 / 0.015	CASE Reg-1 / 0.074 / 0.057 / 0.130 / 0.033	B' Bu Reg-2 / 0.091 / 0.076 / 0.160 / 0.044	irn-up = Reg-3 / 0.122 / 0.096 / 0.210 / 0.053	30 GWa Reg-4 / 0.149 / 0.107 / 0.240 / 0.062	d/t - No Reg-5 / 0.115 / 0.071 / 0.080 / 0.113	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.249	ded – N Reg-7 / 0.125 / 0.169 / 0.050 / 0.195	ine-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.143	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.107
	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI	Country Sweden Germany UK Spain France Sweden Germany France Japan	CAS Reg-1 / 0.008 / 0.006 / 0.020 / 0.167 0.121	E B F Reg-2 / 0.009 / 0.008 / 0.020 / 0.203 0.150	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.255 0.187	= 30 GW Reg-4 / 0.012 / 0.010 / 0.030 / 0.264 0.185	/d/t - FF Reg-5 / 0.040 / 0.032 / 0.030 / 0.040 0.053	<pre>Pinclude Reg-6 / 0.262 / 0.262 / 0.250 / 0.019 0.092</pre>	d – Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.020 0.087	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.200 / 0.017 0.070	ofile Reg-9 / 0.177 / 0.178 / 0.170 / 0.170 / 0.015 0.054	CASE Reg-1 / 0.074 / 0.057 / 0.130 / 0.033 0.071	B' Bu Reg-2 / 0.091 / 0.076 / 0.160 / 0.044 0.090	Irn-up = Reg-3 / 0.122 / 0.096 / 0.210 / 0.053 0.119	30 GWa Reg-4 / 0.149 / 0.107 / 0.240 / 0.240 / 0.062 0.133	I/t - No Reg-5 / 0.115 / 0.071 / 0.080 / 0.113 0.096	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.249 0.156	ded – N Reg-7 / 0.125 / 0.169 / 0.050 / 0.195 0.140	ine-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.143 0.108	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.107 0.087
$ \begin{array}{r} # \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan	CAS Reg-1 / 0.008 / 0.006 / 0.020 / 0.167 0.121 0.156	EB F Reg-2 / 0.009 / 0.008 / 0.020 / 0.203 0.150 0.190	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.255 0.187 0.235	= 30 GW Reg-4 / 0.012 / 0.010 / 0.030 / 0.264 0.185 0.232	/d/t - FF Reg-5 / 0.040 / 0.032 / 0.030 / 0.040 0.053 0.037	<pre>Pinclude Reg-6 / 0.262 / 0.262 / 0.250 / 0.019 0.092 0.042</pre>	d - Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.020 0.087 0.043	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.200 / 0.017 0.070 0.035	ofile Reg-9 / 0.177 / 0.178 / 0.170 / 0.170 / 0.015 0.054 0.030	CASE Reg-1 / 0.074 / 0.057 / 0.130 / 0.033 0.071 0.079	B' Bu Reg-2 / 0.091 / 0.076 / 0.160 / 0.044 0.090 0.098	Irm-up = Reg-3 / 0.122 / 0.096 / 0.210 / 0.053 0.119 0.129	30 GWc Reg-4 / 0.149 / 0.107 / 0.240 / 0.062 0.133 0.150	l/t - No Reg-5 / 0.115 / 0.071 / 0.080 / 0.113 0.096 0.097	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.249 0.156 0.147	ded – N Reg-7 / 0.125 / 0.169 / 0.050 / 0.195 0.140 0.128	ine-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.143 0.108 0.096	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.107 0.087 0.076
$ \begin{array}{r} # \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan	CAS Reg-1 / 0.008 / 0.006 / 0.020 / 0.167 0.121 0.156 0.129	EB F Reg-2 / 0.009 / 0.008 / 0.020 / 0.203 0.150 0.190 0.158	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.255 0.187 0.235 0.194	= 30 GW Reg-4 / 0.012 / 0.010 / 0.030 / 0.264 0.185 0.232 0.193	/d/t - FF Reg-5 / 0.040 / 0.032 / 0.030 / 0.040 0.053 0.037 0.034	<pre>Pinclude Reg-6 / 0.262 / 0.262 / 0.250 / 0.019 0.092 0.042 0.083</pre>	d - Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.250 / 0.250 / 0.020 0.087 0.043 0.084	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.200 / 0.0017 0.070 0.035 0.068	ofile Reg-9 / 0.177 / 0.178 / 0.178 / 0.170 / 0.015 0.054 0.030 0.057	CASE Reg-1 / 0.074 / 0.057 / 0.130 / 0.033 0.071 0.079 0.107	B' Bt Reg-2 / 0.091 / 0.076 / 0.040 / 0.044 0.090 0.098 0.136	Irm-up = Reg-3 / 0.122 / 0.096 / 0.210 / 0.053 0.119 0.129 0.182	30 GWc Reg-4 / 0.149 / 0.107 / 0.240 / 0.062 0.133 0.150 0.212	l/t - No Reg-5 / 0.115 / 0.071 / 0.080 / 0.080 / 0.096 0.097 0.081	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.249 0.156 0.147 0.096	ded – N Reg-7 / 0.125 / 0.169 / 0.050 / 0.195 0.140 0.128 0.077	ine-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.143 0.108 0.096 0.060	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.030 / 0.087 0.076 0.048
$ \begin{array}{r} # \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA	CAS Reg-1 / 0.008 / 0.006 / 0.020 / 0.167 0.121 0.156 0.129 0.154	E B F Reg-2 / 0.009 / 0.008 / 0.008 / 0.020 / 0.203 0.150 0.190 0.158 0.189	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.255 0.187 0.235 0.194 0.229	= 30 GW Reg-4 / 0.012 / 0.010 / 0.030 / 0.264 0.185 0.232 0.193 0.231	/d/t - FF Reg-5 / 0.040 / 0.032 / 0.030 / 0.040 0.053 0.037 0.034 0.040	rinclude Reg-6 / 0.262 / 0.262 / 0.250 / 0.019 0.092 0.042 0.083 0.046	d - Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.250 / 0.020 0.087 0.043 0.084 0.045	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.017 0.017 0.070 0.035 0.068 0.036	ofile Reg-9 / 0.177 / 0.178 / 0.170 / 0.015 0.054 0.030 0.057 0.030	CASE Reg-1 / 0.074 / 0.057 / 0.130 / 0.033 0.071 0.079 0.107 0.102	B' Bt Reg-2 / 0.091 / 0.076 / 0.076 / 0.044 0.090 0.098 0.136 0.128	Irm-up = Reg-3 / 0.122 / 0.096 / 0.210 / 0.053 0.119 0.129 0.182 0.168	30 GWc Reg-4 / 0.149 / 0.107 / 0.240 / 0.062 0.133 0.150 0.212 0.192	l/t - No Reg-5 / 0.115 / 0.071 / 0.080 / 0.113 0.096 0.097 0.081 0.121	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.249 0.156 0.147 0.096 0.093	ded – N Reg-7 / 0.125 / 0.169 / 0.050 / 0.195 0.140 0.128 0.077 0.082	ine-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.143 0.108 0.096 0.060 0.064	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.030 / 0.030 / 0.076 0.048 0.051
$ \begin{array}{r} # \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL PNC	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan	CAS Reg-1 / 0.008 / 0.006 / 0.020 / 0.167 0.121 0.156 0.129 0.154 0.081	EB F Reg-2 / 0.009 / 0.008 / 0.008 / 0.020 / 0.203 0.150 0.190 0.158 0.189 0.105	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.255 0.187 0.235 0.194 0.229 0.129	= 30 GW Reg-4 / 0.012 / 0.010 / 0.030 / 0.264 0.185 0.232 0.193 0.231 0.124	/d/t - FF Reg-5 / 0.040 / 0.032 / 0.030 / 0.053 0.037 0.034 0.040 0.040 0.048	rinclude Reg-6 / 0.262 / 0.262 / 0.250 / 0.0250 / 0.019 0.092 0.042 0.083 0.046 0.146	d - Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.250 / 0.0250 / 0.020 0.087 0.043 0.084 0.045 0.151	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.0200 / 0.0017 0.070 0.035 0.068 0.036 0.120	ofile Reg-9 / 0.177 / 0.178 / 0.170 / 0.015 0.054 0.030 0.057 0.030 0.096	CASE Reg-1 / 0.074 / 0.057 / 0.130 / 0.033 0.071 0.079 0.107 0.102 0.073	B' Bt Reg-2 / 0.091 / 0.076 / 0.076 / 0.044 0.090 0.098 0.136 0.128 0.097	Im-up = Reg-3 / 0.122 / 0.096 / 0.210 / 0.210 / 0.053 0.119 0.129 0.182 0.168 0.126	30 GWc Reg-4 / 0.149 / 0.107 / 0.240 / 0.062 0.133 0.150 0.212 0.192 0.146	l/t - No Reg-5 / 0.115 / 0.071 / 0.080 / 0.113 0.096 0.097 0.081 0.121 0.106	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.249 0.156 0.147 0.096 0.093 0.152	ded – N Reg-7 / 0.125 / 0.169 / 0.050 / 0.195 0.140 0.128 0.077 0.082 0.130	ine-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.143 0.108 0.096 0.060 0.064 0.097	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.030 / 0.076 0.048 0.051 0.073
$ \begin{array}{r} #\\ 1\\ 2\\ 3\\ 4\\ 5\\ 6\\ 7\\ 8\\ 9\\ 10\\ 11\\ 12\\ 13\\ 14\\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL PNC UKDOT	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan UK	CAS Reg-1 / 0.008 / 0.006 / 0.020 / 0.167 0.121 0.156 0.129 0.154 0.081 0.045	EB F Reg-2 / 0.009 / 0.008 / 0.008 / 0.020 / 0.203 0.150 0.150 0.190 0.158 0.189 0.105 0.054	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.255 0.187 0.235 0.194 0.229 0.129 0.069	= 30 GW Reg-4 / 0.012 / 0.010 / 0.030 / 0.264 0.185 0.232 0.193 0.231 0.124 0.070	/d/t - FF Reg-5 / 0.040 / 0.032 / 0.030 / 0.040 0.053 0.037 0.034 0.040 0.040 0.048 0.029	rinclude Reg-6 / 0.262 / 0.262 / 0.250 / 0.0250 / 0.019 0.042 0.042 0.083 0.046 0.146 0.213	d - Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.250 / 0.250 / 0.020 0.087 0.043 0.084 0.045 0.151 0.211	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.017 0.017 0.070 0.035 0.068 0.036 0.120 0.167	ofile Reg-9 / 0.177 / 0.178 / 0.170 / 0.015 0.054 0.054 0.030 0.057 0.030 0.096 0.142	CASE Reg-1 / 0.074 / 0.057 / 0.130 / 0.033 0.071 0.079 0.107 0.102 0.073 0.066	B' Bt Reg-2 / 0.091 / 0.076 / 0.076 / 0.060 / 0.044 0.090 0.098 0.136 0.128 0.097 0.084	Im-up = Reg-3 / 0.122 / 0.096 / 0.210 / 0.210 / 0.053 0.119 0.129 0.182 0.168 0.126 0.112	30 GWc Reg-4 / 0.149 / 0.107 / 0.240 / 0.240 / 0.062 0.133 0.150 0.212 0.192 0.146 0.131	l/t - No Reg-5 / 0.115 / 0.071 / 0.080 / 0.080 / 0.096 0.097 0.081 0.121 0.106 0.095	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.249 0.156 0.147 0.096 0.093 0.152 0.165	ded – N Reg-7 / 0.125 / 0.169 / 0.050 / 0.195 0.140 0.128 0.077 0.082 0.130 0.146	ine-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.143 0.096 0.060 0.064 0.097 0.110	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.030 / 0.007 0.087 0.076 0.048 0.051 0.073 0.090
$ \begin{array}{r} # \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL PNC UKDOT	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan USA Japan UK Average	CAS Reg-1 / 0.008 / 0.006 / 0.020 / 0.167 0.121 0.156 0.129 0.154 0.081 0.045 0.089	E B F Reg-2 / 0.009 / 0.008 / 0.008 / 0.020 / 0.203 0.150 0.190 0.158 0.189 0.105 0.054 0.109	Burn-up Reg-3 / 0.011 / 0.010 / 0.030 / 0.255 0.187 0.235 0.194 0.229 0.129 0.069 0.135	= 30 GW Reg-4 / 0.012 / 0.010 / 0.030 / 0.264 0.185 0.232 0.193 0.231 0.124 0.070 0.135	/d/t - FF Reg-5 / 0.040 / 0.032 / 0.030 / 0.040 0.053 0.037 0.034 0.040 0.048 0.029 0.038	rinclude Reg-6 / 0.262 / 0.262 / 0.250 / 0.019 0.092 0.042 0.042 0.083 0.046 0.146 0.213 0.141	d - Nine Reg-7 / 0.265 / 0.270 / 0.250 / 0.020 0.087 0.043 0.043 0.045 0.151 0.211 0.143	-zone pr Reg-8 / 0.217 / 0.225 / 0.200 / 0.017 0.070 0.035 0.068 0.036 0.120 0.167 0.116	ofile           Reg-9           /           0.177           /           0.178           /           0.170           /           0.015           0.054           0.030           0.057           0.030           0.096           0.142           0.095	CASE Reg-1 / 0.074 / 0.057 / 0.130 / 0.033 0.071 0.079 0.107 0.102 0.073 0.066 0.079	B' Bt Reg-2 / 0.091 / 0.076 / 0.076 / 0.044 0.090 0.098 0.136 0.128 0.097 0.084 0.100	Im-up = Reg-3 / 0.122 / 0.096 / 0.210 / 0.210 / 0.053 0.119 0.129 0.182 0.168 0.126 0.112 0.132	30 GWa Reg-4 / 0.149 / 0.107 / 0.240 / 0.062 0.133 0.150 0.212 0.192 0.146 0.131 0.152	I/t - No Reg-5 / 0.115 / 0.071 / 0.080 / 0.113 0.096 0.097 0.081 0.121 0.106 0.095 0.097	FP inclu Reg-6 / 0.152 / 0.186 / 0.060 / 0.249 0.156 0.147 0.096 0.093 0.152 0.165 0.146	ded – N Reg-7 / 0.125 / 0.125 / 0.169 / 0.050 / 0.195 0.140 0.128 0.077 0.082 0.130 0.146 0.124	ine-zone Reg-8 / 0.097 / 0.134 / 0.040 / 0.143 0.108 0.096 0.060 0.064 0.097 0.110 0.095	profile Reg-9 / 0.076 / 0.104 / 0.030 / 0.030 / 0.077 0.087 0.076 0.048 0.051 0.073 0.090 0.074

			CA	SE C	Burn-uj	p = 50 G	Wd/t – I	FP incluc	ded – No	BU pro	file	CASI	E C' I	Burn-up	= 50 GV	Vd/t – N	o FP incl	luded – l	No BU p	orofile
#	Institute	Country	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9
1	ABB	Sweden	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
2	BfS-IKE	Germany	0.030	0.041	0.065	0.110	0.355	0.153	0.112	0.077	0.058	0.021	0.028	0.041	0.073	0.292	0.235	0.144	0.091	0.073
3	BNFL	UK	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
4	CSN	Spain	0.040	0.057	0.084	0.138	0.354	0.140	0.086	0.058	0.043	0.040	0.057	0.084	0.138	0.355	0.140	0.086	0.058	0.042
5	CEA	France	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
6	EMS	Sweden	0.030	0.040	0.070	0.100	0.230	0.230	0.140	0.090	0.070	0.050	0.070	0.110	0.200	0.340	0.100	0.050	0.040	0.030
7	GRS	Germany	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
8	IPSN	France	0.009	0.014	0.022	0.043	0.604	0.150	0.079	0.050	0.028	0.009	0.014	0.026	0.047	0.304	0.274	0.157	0.100	0.070
9	JAERI	Japan	0.030	0.046	0.070	0.118	0.444	0.140	0.076	0.048	0.029	0.029	0.040	0.057	0.103	0.425	0.155	0.089	0.060	0.042
10	JINS-1	Japan	0.047	0.063	0.093	0.139	0.317	0.142	0.090	0.063	0.047	0.050	0.068	0.099	0.150	0.317	0.136	0.083	0.056	0.040
11	JINS-2	Japan	0.053	0.070	0.105	0.168	0.339	0.111	0.070	0.049	0.036	0.043	0.059	0.088	0.144	0.317	0.143	0.095	0.063	0.048
12	ORNL	USA	0.032	0.046	0.067	0.108	0.360	0.167	0.100	0.067	0.054	0.052	0.068	0.106	0.165	0.318	0.118	0.076	0.054	0.043
13	PNC	Japan	0.037	0.056	0.093	0.140	0.296	0.145	0.103	0.075	0.056	0.051	0.051	0.094	0.150	0.267	0.163	0.103	0.069	0.051
14	UKDOT	UK	0.042	0.057	0.087	0.163	0.339	0.135	0.083	0.056	0.039	0.042	0.056	0.089	0.159	0.377	0.123	0.070	0.047	0.036
		Average	0.035	0.049	0.075	0.123	0.364	0.151	0.094	0.063	0.046	0.039	0.051	0.079	0.133	0.331	0.159	0.095	0.064	0.048
		2 * <b>σ</b> .	62%	57%	55%	53%	50%	37%	40%	40%	54%	68%	65%	65%	62%	25%	62%	62%	53%	52%
	L	= •1		0170	2273	0070	0070	2.1.0		, .		0010	0070	0070	0 = 7.0	== / =	01/0		0010	0-/0
	L		CAS	ED E	Burn-up	= 50 GW	$\frac{d}{t} - FF$	' include	ed – Nine	-zone pi	ofile	CASE	<b>D'</b> Bi	rn-up =	50 GWa	d/t - No	FP inclu	ded – Ni	ine-zone	profile
#	Institute	Country	CAS Reg-1	ED E Reg-2	Burn-up Reg-3	= 50 GW Reg-4	/d/t – FF Reg-5	include Reg-6	d – Nine Reg-7	-zone pi Reg-8	ofile Reg-9	CASE Reg-1	D' Bu Reg-2	rn-up = Reg-3	50 GWo Reg-4	d/t – No Reg-5	FP inclu Reg-6	ded – Ni Reg-7	ine-zone Reg-8	profile Reg-9
#	Institute ABB	Country Sweden	CAS Reg-1	<b>E D</b> H Reg-2	Burn-up Reg-3	= 50 GW Reg-4 /	/d/t – FF Reg-5 /	include Reg-6	ed – Nine Reg-7	-zone pi Reg-8 /	rofile Reg-9 /	CASE Reg-1	D' Bu Reg-2 /	$\frac{\text{irn-up} =}{\text{Reg-3}}$	50 GWc Reg-4 /	d/t – No Reg-5 /	FP inclu Reg-6	ded – Ni Reg-7 /	ine-zone Reg-8	profile Reg-9 /
# 1 2	Institute ABB BfS-IKE	Country Sweden Germany	CAS Reg-1 / 0.140	<b>E D</b> H Reg-2 / 0.166	Burn-up Reg-3 / 0.184	= 50 GW Reg-4 / 0.146	Vd/t – FP Reg-5 / 0.013	• include Reg-6 / 0.086	ed – Nine Reg-7 / 0.102	-zone pi Reg-8 / 0.089	rofile Reg-9 / 0.074	CASE Reg-1 / 0.085	<b>D'</b> Bu Reg-2 / 0.106	$\frac{\text{urn-up} =}{\text{Reg-3}}$ $\frac{1}{0.128}$	50 GWa Reg-4 / 0.123	d/t - No Reg-5 / 0.033	FP inclu Reg-6 / 0.139	ded – Ni Reg-7 / 0.151	ine-zone Reg-8 / 0.128	profile Reg-9 / 0.108
# 1 2 3	Institute ABB BfS-IKE BNFL	Country Sweden Germany UK	CAS Reg-1 / 0.140 /	E D E Reg-2 / 0.166 /	Burn-up Reg-3 / 0.184 /	= 50 GW Reg-4 / 0.146 /	Vd/t - FF Reg-5 / 0.013 /	P include Reg-6 / 0.086 /	d – Nine Reg-7 / 0.102 /	-zone pr Reg-8 / 0.089 /	rofile Reg-9 / 0.074 /	CASE Reg-1 / 0.085 /	D' Bu Reg-2 / 0.106 /	irn-up = Reg-3 / 0.128 /	50 GWa Reg-4 / 0.123 /	d/t - No Reg-5 / 0.033 /	FP inclu Reg-6 / 0.139 /	ded – Ni Reg-7 / 0.151 /	ine-zone Reg-8 / 0.128 /	profile Reg-9 / 0.108 /
# 1 2 3 4	Institute ABB BfS-IKE BNFL CSN	Country Sweden Germany UK Spain	CAS Reg-1 / 0.140 / 0.000	E D E Reg-2 / 0.166 / 0.000	Burn-up Reg-3 / 0.184 / 0.000	= 50 GW Reg-4 / 0.146 / 0.000	/d/t - FF Reg-5 / 0.013 / 0.012	<pre>Pinclude Reg-6 / 0.086 / 0.220</pre>	d – Nine Reg-7 / 0.102 / 0.287	-zone pr Reg-8 / 0.089 / 0.264	rofile Reg-9 / 0.074 / 0.217	CASE Reg-1 / 0.085 / 0.002	D' Bu Reg-2 / 0.106 / 0.002	urn-up = Reg-3 / 0.128 / 0.003	50 GWa Reg-4 / 0.123 / 0.002	l/t – No Reg-5 / 0.033 / 0.023	FP inclu Reg-6 / 0.139 / 0.253	ded – Ni Reg-7 / 0.151 / 0.281	ine-zone Reg-8 / 0.128 / 0.242	profile Reg-9 / 0.108 / 0.193
# 1 2 3 4 5	Institute ABB BfS-IKE BNFL CSN CEA	Country Sweden Germany UK Spain France	CAS Reg-1 / 0.140 / 0.000 /	E D E Reg-2 / 0.166 / 0.000 /	Burn-up Reg-3 / 0.184 / 0.000 /	= 50 GW Reg-4 / 0.146 / 0.000 /	Vd/t - FF Reg-5 / 0.013 / 0.012 /	<pre>include Reg-6     /     0.086     /     0.220     / </pre>	d – Nine Reg-7 / 0.102 / 0.287 /	-zone pr Reg-8 / 0.089 / 0.264 /	rofile Reg-9 / 0.074 / 0.217 /	CASE Reg-1 / 0.085 / 0.002 /	D' Bu Reg-2 / 0.106 / 0.002 /	or-up =           Reg-3           /           0.128           /           0.003           /	50 GWc Reg-4 / 0.123 / 0.002 /	d/t - No Reg-5 / 0.033 / 0.023 /	FP inclu Reg-6 / 0.139 / 0.253 /	ded – Ni Reg-7 / 0.151 / 0.281 /	ine-zone Reg-8 / 0.128 / 0.242 /	profile Reg-9 / 0.108 / 0.193 /
	Institute ABB BfS-IKE BNFL CSN CEA EMS	Country Sweden Germany UK Spain France Sweden	CAS Reg-1 / 0.140 / 0.000 / 0.139	E D E Reg-2 / 0.166 / 0.000 / 0.158	Burn-up Reg-3 / 0.184 / 0.000 / 0.178	= 50 GW Reg-4 / 0.146 / 0.000 / 0.139	Vd/t - FF Reg-5 / 0.013 / 0.012 / 0.010	<pre>include Reg-6     /     0.086     /     0.220     /     0.089</pre>	rd – Nine Reg-7 / 0.102 / 0.287 / 0.109	-zone pr Reg-8 / 0.089 / 0.264 / 0.099	rofile Reg-9 / 0.074 / 0.217 / 0.079	CASE Reg-1 / 0.085 / 0.002 / 0.178	D' Bu Reg-2 / 0.106 / 0.002 / 0.218	arn-up =           Reg-3           /           0.128           /           0.003           /           0.257	50 GWa Reg-4 / 0.123 / 0.002 / 0.248	d/t - No Reg-5 / 0.033 / 0.023 / 0.030	FP inclu Reg-6 / 0.139 / 0.253 / 0.020	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020	ine-zone Reg-8 / 0.128 / 0.242 / 0.020	profile Reg-9 / 0.108 / 0.193 / 0.010
# 1 2 3 4 5 6 7	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS	Country Sweden Germany UK Spain France Sweden Germany	CAS Reg-1 / 0.140 / 0.000 / 0.139 /	E D E Reg-2 / 0.166 / 0.000 / 0.158 /	Burn-up Reg-3 / 0.184 / 0.000 / 0.178 /	= 50 GW Reg-4 / 0.146 / 0.000 / 0.139 /	Vd/t - FF Reg-5 / 0.013 / 0.012 / 0.010 /	<pre>include Reg-6 / 0.086 / 0.220 / 0.089 /</pre>	d - Nine Reg-7 / 0.102 / 0.287 / 0.109 /	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 /	ofile Reg-9 / 0.074 / 0.217 / 0.079 /	CASE Reg-1 / 0.085 / 0.002 / 0.178 /	D'         Bu           Reg-2         /           0.106         /           0.002         /           0.218         /	or-up =           Reg-3           /           0.128           /           0.003           /           0.257           /	50 GWa Reg-4 / 0.123 / 0.002 / 0.248 /	d/t - No Reg-5 / 0.033 / 0.023 / 0.030 /	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 /	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 /	ine-zone Reg-8 / 0.128 / 0.242 / 0.020 /	profile Reg-9 / 0.108 / 0.193 / 0.010 /
# 1 2 3 4 5 6 7 8	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN	Country Sweden Germany UK Spain France Sweden Germany France	CAS Reg-1 / 0.140 / 0.000 / 0.139 / 0.211	E D E Reg-2 / 0.166 / 0.000 / 0.158 / 0.248	Burn-up Reg-3 / 0.184 / 0.000 / 0.178 / 0.280	= 50 GW Reg-4 / 0.146 / 0.000 / 0.139 / 0.220	Vd/t - FF Reg-5 / 0.013 / 0.012 / 0.010 / 0.010 / 0.012	<pre>include Reg-6     /     0.086     /     0.220     /     0.089     /     0.006</pre>	d – Nine Reg-7 / 0.102 / 0.287 / 0.109 / 0.009	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.008	rofile Reg-9 / 0.074 / 0.217 / 0.079 / 0.006	CASE Reg-1 / 0.085 / 0.002 / 0.178 / 0.119	D' Bu Reg-2 / 0.106 / 0.002 / 0.218 / 0.151	0.128 / 0.128 / 0.003 / 0.257 / 0.187	50 GWc Reg-4 / 0.123 / 0.002 / 0.248 / 0.175	d/t - No Reg-5 / 0.033 / 0.023 / 0.030 / 0.030 / 0.028	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.092	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.102	ine-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.082	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.064
# 1 2 3 4 5 6 7 8 9	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI	Country Sweden Germany UK Spain France Sweden Germany France Japan	CAS Reg-1 / 0.140 / 0.000 / 0.139 / 0.211 0.140	E D E Reg-2 / 0.166 / 0.000 / 0.158 / 0.248 0.165	Burn-up Reg-3 / 0.184 / 0.000 / 0.178 / 0.280 0.183	= 50 GW Reg-4 / 0.146 / 0.000 / 0.139 / 0.220 0.142	/d/t - FF Reg-5 / 0.013 / 0.012 / 0.010 / 0.010 / 0.012 0.012	<pre>include Reg-6 / 0.086 / 0.220 / 0.089 / 0.006 0.080</pre>	d - Nine Reg-7 / 0.102 / 0.287 / 0.109 / 0.009 0.103	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.008 0.094	ofile Reg-9 / 0.074 / 0.217 / 0.079 / 0.006 0.081	CASE Reg-1 / 0.085 / 0.002 / 0.178 / 0.119 0.053	D' Bu Reg-2 / 0.106 / 0.002 / 0.218 / 0.151 0.065	m-up = Reg-3 / 0.128 / 0.003 / 0.257 / 0.187 0.078	50 GWa Reg-4 / 0.123 / 0.002 / 0.248 / 0.175 0.073	I/t - No           Reg-5           /           0.033           /           0.023           /           0.030           /           0.028           0.026	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.092 0.188	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.102 0.203	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.082 0.172	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.064 0.141
# 1 2 3 4 5 6 7 8 9 9 10	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS GRS IPSN JAERI JINS-1	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan	CAS Reg-1 / 0.140 / 0.000 / 0.139 / 0.211 0.140 0.113	E D E Reg-2 / 0.166 / 0.000 / 0.158 / 0.248 0.165 0.132	Burn-up Reg-3 / 0.184 / 0.000 / 0.178 / 0.280 0.183 0.150	= 50 GW Reg-4 / 0.146 / 0.000 / 0.139 / 0.220 0.142 0.119	/d/t - FF Reg-5 / 0.013 / 0.012 / 0.012 / 0.012 0.012 0.012 0.012	<pre>include Reg-6 / 0.086 / 0.220 / 0.089 / 0.006 0.080 0.110</pre>	d - Nine Reg-7 / 0.102 / 0.287 / 0.109 / 0.109 0.103 0.137	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.008 0.094 0.122	ofile           Reg-9           /           0.074           /           0.217           /           0.079           /           0.006           0.081           0.102	CASE Reg-1 / 0.085 / 0.002 / 0.178 / 0.119 0.053 0.068	D' Bu Reg-2 / 0.106 / 0.002 / 0.218 / 0.151 0.065 0.082	Inn-up = Reg-3 / 0.128 / 0.003 / 0.257 / 0.187 0.078 0.100	50 GWa Reg-4 / 0.123 / 0.002 / 0.248 / 0.175 0.073 0.096	I/t - No           Reg-5           /           0.033           /           0.023           /           0.030           /           0.028           0.026           0.032	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.092 0.188 0.171	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.102 0.203 0.177	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.082 0.172 0.151	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.064 0.141 0.123
# 1 2 3 4 5 6 7 8 9 9 10 11	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan	CAS Reg-1 / 0.140 / 0.000 / 0.139 / 0.211 0.140 0.113 0.099	E D E Reg-2 / 0.166 / 0.000 / 0.158 / 0.248 0.165 0.132 0.115	Burn-up Reg-3 / 0.184 / 0.000 / 0.178 / 0.280 0.183 0.150 0.129	= 50 GW Reg-4 / 0.146 / 0.000 / 0.139 / 0.220 0.142 0.119 0.104	/d/t - FF Reg-5 / 0.013 / 0.012 / 0.012 / 0.012 0.012 0.012 0.012 0.014 0.014	<pre>include Reg-6 / 0.086 / 0.220 / 0.089 / 0.006 0.080 0.110 0.127</pre>	d - Nine Reg-7 / 0.102 / 0.287 / 0.109 / 0.009 0.103 0.137 0.155	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.008 0.094 0.122 0.138	rofile Reg-9 / 0.074 / 0.217 / 0.079 / 0.006 0.081 0.102 0.118	CASE Reg-1 / 0.085 / 0.002 / 0.178 / 0.119 0.053 0.068 0.068	D' Bu Reg-2 / 0.106 / 0.002 / 0.218 / 0.151 0.065 0.082 0.083	Inn-up = Reg-3 / 0.128 / 0.003 / 0.257 / 0.187 0.078 0.100 0.098	50 GWa Reg-4 / 0.123 / 0.002 / 0.002 / 0.248 / 0.175 0.073 0.096 0.091	I/t - No           Reg-5           /           0.033           /           0.023           /           0.030           /           0.028           0.026           0.032           0.031	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.092 0.188 0.171 0.178	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.102 0.203 0.177 0.181	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.082 0.172 0.151 0.147	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.064 0.141 0.123 0.122
# 1 2 3 4 5 6 7 8 9 10 11 12	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-2 ORNL	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA	CAS Reg-1 / 0.140 / 0.000 / 0.139 / 0.211 0.140 0.113 0.099 0.044	E D E Reg-2 / 0.166 / 0.000 / 0.158 / 0.158 / 0.248 0.165 0.132 0.115 0.053	Burn-up Reg-3 / 0.184 / 0.000 / 0.178 / 0.280 0.183 0.150 0.129 0.061	= 50 GW Reg-4 / 0.146 / 0.000 / 0.139 / 0.220 0.142 0.119 0.104 0.049	/d/t - FF Reg-5 / 0.013 / 0.012 / 0.012 / 0.012 0.012 0.012 0.012 0.012 0.014 0.014 0.013	rinclude Reg-6 / 0.086 / 0.220 / 0.089 / 0.006 0.080 0.110 0.127 0.177	d - Nine Reg-7 / 0.102 / 0.287 / 0.109 / 0.109 / 0.009 0.103 0.137 0.155 0.223	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.008 0.094 0.122 0.138 0.204	ofile           Reg-9           /           0.074           /           0.217           /           0.079           /           0.006           0.081           0.102           0.118           0.176	CASE Reg-1 / 0.085 / 0.002 / 0.178 / 0.119 0.053 0.068 0.068 0.057	D' Bu Reg-2 / 0.106 / 0.002 / 0.218 / 0.151 0.065 0.082 0.083 0.067	urn-up           Reg-3           /           0.128           /           0.003           /           0.257           /           0.187           0.078           0.100           0.098           0.080	50 GWa Reg-4 / 0.123 / 0.002 / 0.248 / 0.175 0.073 0.096 0.091 0.074	I/t - No           Reg-5           /           0.033           /           0.023           /           0.030           /           0.030           /           0.028           0.026           0.032           0.031           0.027	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.092 0.188 0.171 0.178 0.187	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.102 0.203 0.177 0.181 0.199	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.082 0.172 0.151 0.147 0.167	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.064 0.141 0.123 0.122 0.141
# 1 2 3 4 5 6 7 8 9 10 11 12 13	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS GRS JAERI JINS-1 JINS-2 ORNL ORNL PNC	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan	CAS           Reg-1           /           0.140           /           0.000           /           0.139           /           0.211           0.140           0.140           0.140           0.140           0.140           0.140           0.140           0.113           0.099           0.044           0.114	E D E Reg-2 / 0.166 / 0.000 / 0.158 / 0.158 / 0.248 0.165 0.132 0.115 0.053 0.137	Burn-up Reg-3 / 0.184 / 0.000 / 0.178 / 0.178 / 0.280 0.183 0.150 0.129 0.061 0.151	= 50 GW Reg-4 / 0.146 / 0.000 / 0.139 / 0.220 0.142 0.119 0.104 0.049 0.124	/d/t - FF Reg-5 / 0.013 / 0.012 / 0.012 / 0.012 0.012 0.012 0.012 0.014 0.014 0.013 0.016	<pre>include Reg-6 / 0.086 / 0.220 / 0.089 / 0.006 0.080 0.110 0.127 0.177 0.105</pre>	d - Nine Reg-7 / 0.102 / 0.287 / 0.109 / 0.009 0.103 0.137 0.155 0.223 0.133	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.008 0.094 0.122 0.138 0.204 0.120	ofile Reg-9 / 0.074 / 0.217 / 0.079 / 0.006 0.081 0.102 0.118 0.176 0.100	CASE Reg-1 / 0.085 / 0.002 / 0.178 / 0.178 / 0.119 0.053 0.068 0.068 0.057 0.091	D' Bu Reg-2 / 0.106 / 0.002 / 0.218 / 0.055 0.082 0.083 0.067 0.112	Reg-3 / 0.128 / 0.003 / 0.257 / 0.187 0.078 0.100 0.098 0.080 0.136	50 GWa Reg-4 / 0.123 / 0.002 / 0.248 / 0.175 0.073 0.096 0.091 0.074 0.131	I/t - No           Reg-5           /           0.033           /           0.023           /           0.030           /           0.028           0.026           0.032           0.031           0.027           0.040	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.092 0.188 0.171 0.178 0.187 0.142	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.102 0.203 0.177 0.181 0.199 0.141	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.082 0.172 0.151 0.147 0.167 0.112	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.064 0.141 0.123 0.122 0.141 0.095
$ \begin{array}{r} \# \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-1 JINS-2 ORNL ORNL PNC UKDOT	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan USA Japan	CAS           Reg-1           /           0.140           /           0.000           /           0.139           /           0.211           0.140           0.139           /           0.211           0.140           0.113           0.099           0.044           0.114           0.052	E D E Reg-2 / 0.166 / 0.000 / 0.158 / 0.248 0.165 0.132 0.115 0.053 0.137 0.062	Burn-up Reg-3 / 0.184 / 0.000 / 0.178 / 0.280 0.183 0.150 0.129 0.061 0.151 0.069	= 50 GW Reg-4 / 0.146 / 0.000 / 0.139 / 0.139 / 0.220 0.142 0.119 0.104 0.049 0.124 0.053	/d/t - FF Reg-5 / 0.013 / 0.012 / 0.012 / 0.012 0.012 0.012 0.012 0.014 0.014 0.013 0.016 0.011	<pre>include Reg-6 / 0.086 / 0.220 / 0.089 / 0.006 0.080 0.110 0.127 0.105 0.167</pre>	d - Nine Reg-7 / 0.102 / 0.287 / 0.109 / 0.009 0.103 0.137 0.155 0.223 0.133 0.217	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.008 0.094 0.122 0.138 0.204 0.120 0.199	ofile Reg-9 / 0.074 / 0.217 / 0.079 / 0.006 0.081 0.102 0.118 0.176 0.100 0.170	CASE Reg-1 / 0.085 / 0.002 / 0.178 / 0.119 0.053 0.068 0.068 0.068 0.057 0.091 0.045	D' Bu Reg-2 / 0.106 / 0.002 / 0.218 / 0.151 0.065 0.082 0.083 0.067 0.112 0.054	Inn-up = Reg-3 / 0.128 / 0.003 / 0.003 / 0.257 / 0.187 0.078 0.100 0.098 0.080 0.136 0.066	50 GWa Reg-4 / 0.123 / 0.002 / 0.0248 / 0.175 0.073 0.096 0.091 0.074 0.131 0.063	I/t - No           Reg-5           /           0.033           /           0.023           /           0.030           /           0.028           0.026           0.032           0.031           0.027           0.040	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.092 0.188 0.171 0.178 0.187 0.142 0.197	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.102 0.203 0.177 0.181 0.199 0.141 0.218	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.082 0.172 0.151 0.147 0.167 0.112 0.181	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.064 0.141 0.123 0.122 0.141 0.095 0.148
$ \begin{array}{r} \# \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ \end{array} $	Institute ABB BfS-IKE BNFL CSN CEA EMS GRS IPSN JAERI JINS-1 JINS-1 JINS-2 ORNL PNC UKDOT	Country Sweden Germany UK Spain France Sweden Germany France Japan Japan Japan USA Japan USA Japan UK Average	CAS           Reg-1           /           0.140           /           0.000           /           0.139           /           0.211           0.140           0.113           0.099           0.044           0.114           0.052           0.105	E D E Reg-2 / 0.166 / 0.000 / 0.158 / 0.158 / 0.158 0.165 0.132 0.115 0.053 0.137 0.062 0.124	Burn-up Reg-3 / 0.184 / 0.000 / 0.178 / 0.280 0.183 0.150 0.129 0.061 0.151 0.069 0.139	= 50 GW Reg-4 / 0.146 / 0.000 / 0.139 / 0.139 / 0.139 / 0.120 0.142 0.119 0.104 0.049 0.124 0.053 0.110	/d/t - FF Reg-5 / 0.013 / 0.012 / 0.012 / 0.012 0.012 0.012 0.012 0.014 0.013 0.016 0.011 0.013	<pre>include Reg-6 / 0.086 / 0.220 / 0.089 / 0.006 0.080 0.110 0.127 0.105 0.167 0.117</pre>	d - Nine Reg-7 / 0.102 / 0.287 / 0.109 / 0.109 / 0.009 0.103 0.137 0.155 0.223 0.133 0.217 0.148	-zone pr Reg-8 / 0.089 / 0.264 / 0.099 / 0.008 0.094 0.122 0.138 0.204 0.120 0.199 0.134	ofile Reg-9 / 0.074 / 0.217 / 0.079 / 0.006 0.081 0.102 0.118 0.176 0.100 0.170 0.112	CASE Reg-1 / 0.085 / 0.002 / 0.178 / 0.178 / 0.053 0.068 0.068 0.057 0.091 0.045 0.077	D' Bu Reg-2 / 0.106 / 0.002 / 0.218 / 0.151 0.065 0.082 0.083 0.067 0.112 0.054 0.094	Impune           Reg-3           /           0.128           /           0.003           /           0.257           /           0.128           0.003           /           0.257           /           0.108           0.078           0.0098           0.080           0.136           0.066           0.113	50 GWa Reg-4 / 0.123 / 0.002 / 0.0248 / 0.175 0.073 0.096 0.091 0.074 0.131 0.063 0.107	I/t - No           Reg-5           /           0.033           /           0.023           /           0.030           /           0.028           0.026           0.032           0.031           0.027           0.030	FP inclu Reg-6 / 0.139 / 0.253 / 0.020 / 0.092 0.188 0.171 0.178 0.187 0.142 0.197 0.157	ded – Ni Reg-7 / 0.151 / 0.281 / 0.020 / 0.102 0.203 0.177 0.181 0.199 0.141 0.218 0.167	ne-zone Reg-8 / 0.128 / 0.242 / 0.020 / 0.082 0.172 0.151 0.147 0.167 0.112 0.181 0.140	profile Reg-9 / 0.108 / 0.193 / 0.010 / 0.064 0.141 0.123 0.122 0.141 0.095 0.148 0.114

## Table 10. Normalised fission densities (cont.)
					CASE	E					
	Fresh fuel										
#	Institute	Country	Reg-1	Reg-2	Reg-3	Reg-4	Reg-5	Reg-6	Reg-7	Reg-8	Reg-9
1	ABB	Sweden	/	/	/	/	/	/	/	/	/
2	BfS-IKE	Germany	0.043	0.057	0.092	0.142	0.288	0.159	0.096	0.067	0.055
3	BNFL	UK	/	/	/	/	/	/	/	/	/
4	CSN	Spain	0.040	0.057	0.086	0.138	0.355	0.139	0.085	0.058	0.042
5	CEA	France	/	/	/	/	/	/	/	/	/
6	EMS	Sweden	0.059	0.079	0.119	0.178	0.257	0.129	0.079	0.059	0.040
7	GRS	Germany	/	/	/	/	/	/	/	/	/
8	IPSN	France	0.032	0.045	0.072	0.151	0.407	0.139	0.078	0.045	0.032
9	JAERI	Japan	0.029	0.042	0.066	0.121	0.454	0.127	0.076	0.048	0.037
10	JINS-1	Japan	0.045	0.060	0.090	0.141	0.347	0.135	0.083	0.056	0.044
11	JINS-2	Japan	0.040	0.054	0.079	0.122	0.351	0.147	0.094	0.065	0.048
12	ORNL	USA	0.038	0.047	0.067	0.106	0.264	0.196	0.129	0.086	0.068
13	PNC	Japan	0.039	0.058	0.077	0.126	0.308	0.169	0.106	0.077	0.039
14	UKDOT	UK	0.042	0.059	0.086	0.139	0.364	0.126	0.085	0.057	0.042
		Average	0.041	0.056	0.083	0.136	0.340	0.147	0.091	0.062	0.045
		2 * <b>o</b> <sub>r</sub>	37%	34%	34%	26%	33%	27%	32%	37%	42%

Table 10. Normalised fission densities (cont.)



Figure 1



SideView (cask)

Figure 2

Note: drawing is not to scale





## Figure 4

# **Fission fractions - Flat burnup profile**



## Figure 4bis











# Figure 5bis

# Fission densities - Nine-zone profile



Figure 6

### Precise representation of Fission Density calculated by J. Stewart





## Precise representation of Neutron Flux Distribution calculated by J. Conde



### Figure 8

## Precise representation of Neutron Flux Distribution calculated by J. Conde





**Case A - Fission fractions** 



# Figure 9bis























# Figure 11bis







**Case D - Fission fractions** 



# Figure 12bis







**Case E - Fission fractions** 



# Figure 13bis





# **APPENDIX 1**

## Material and geometrical description

# Fuel assembly (based on Westinghouse 17×17 design)

Fuel rod data	
Fuel diameter	0.8192 cm
Rod ID	0.8357 cm
Rod OD	0.9500 cm
Fuel length	365.7 cm
Fuel material	UO <sub>2</sub> (assumed isotopic composition from Phase II-A
	4.5 wt% 30 GWd/t fuel, 5 y cooling time)
Clad material	Zircaloy
Gas gap	Void
Endplug material	Zircaloy
Endplug height	1.75 cm
Full rod length	369.2  cm (fuel + 2  endplug)
Upper hardware	30.0 cm
Lower hardware	10.0 cm
Upper water region	7.0 cm
Lower water region	0.0 cm
Axial fuel division (9 axial regions)	
Region 1 (fuel top)	5 cm
Region 2	5 cm
Region 3	10 cm
Region 4	20 cm
Region 5	285.7 cm
Region 6	20 cm
Region 7	10 cm
Region 8	5 cm
Region 9	5 cm
Assembly data	
Lattice	17×17 (289 fuel rods, no guide tubes)
Dimensions	21.41728×21.41728×409.2 cm <sup>3</sup>
Pitch	1.25984 cm
Moderator	Water
Upper and lower end	50% stainless steel, 50% H <sub>2</sub> O (by volume)
Hardware	(Note: rather than attempt to model the detail of the assembly
	end hardware, it has been chosen to mock up the hardware as
	a region of smeared water and stainless steel. Other hardware
	(e.g., grid spacers) is ignored.

### Cask

## Cask shell

ID	136.0 cm
OD	196.0 cm
Material	Stainless steel (SS304)
Height (outside)	476.2 cm
Height (inner cavity)	416.2 cm

### Assembly basket

Inner basket compartment	22 cm×22 cm×416.2 cm (per assembly's position)
dimensions	
Material	Borated stainless steel (1 wt % boron)
Basket wall thickness	1 cm

### Configuration

21 assembly positions in a  $5 \times 5$  array (no corner positions) Fuel assemblies are centred within basket region Cask is completely flooded with water

## Material compositions (densities in atom/barn-cm)

Zircaloy	Cr	7.589 <sup>E</sup> -05
-	Fe	1.484 <sup>E</sup> -04
	Zr	4.298 <sup>E</sup> -02
Water	Н	6.662 <sup>E</sup> -04
	0	3.331 <sup>E</sup> -02
Stainless steel	Cr	1.743 <sup>E</sup> -02
	Mn	1.736 <sup>E</sup> -03
	Fe	5.936 <sup>E</sup> -02
	Ni	7.721 <sup>E</sup> -03
Borated (1 wt %)	Cr	1.691 <sup>E</sup> -02
stainless steel	Mn	1.684 <sup>E</sup> -03
	Fe	5.758 <sup>E</sup> -02
	Ni	7.489 <sup>E</sup> -03
	$^{10}\mathbf{B}$	7.836 <sup>E</sup> -04
	<sup>11</sup> <b>B</b>	3.181 <sup>E</sup> -03
50/50 stainless steel/	Cr	8.714 <sup>E</sup> -02
water mixture	Mn	8.682 <sup>E</sup> -04
	Fe	2.968 <sup>E</sup> -02
	Ni	3.860 <sup>E</sup> -03
	Н	3.338 <sup>E</sup> -02
	0	1.669 <sup>E</sup> -02

## **APPENDIX 2**

## Spent fuel composition

Average B	U = 30  GWd/t	Average $BU = 50 \text{ GWd/t}$		
5 years	cooling time	5 years	cooling time	
<sup>234</sup> U	5.83E-06	<sup>234</sup> U	4.56E-06	
<sup>235</sup> U	4.33E-04	<sup>235</sup> U	2.07E-04	
<sup>236</sup> U	1.16E-04	<sup>236</sup> U	1.46E-04	
<sup>238</sup> U	2.16E-02	<sup>238</sup> U	2.12E-02	
<sup>238</sup> Pu	2.60E-06	<sup>238</sup> Pu	8.69E-06	
<sup>239</sup> Pu	1.42E-04	<sup>239</sup> Pu	1.53E-04	
<sup>240</sup> Pu	3.84E-05	<sup>240</sup> Pu	6.15E-05	
<sup>241</sup> Pu	2.14E-05	<sup>241</sup> Pu	3.43E-05	
<sup>242</sup> Pu	5.39E-06	<sup>242</sup> Pu	1.71E-05	
<sup>241</sup> Am	6.50E-06	<sup>241</sup> Am	1.08E-05	
<sup>243</sup> Am	9.10E-07	<sup>243</sup> Am	4.81E-06	
<sup>237</sup> Np	1.07E-05	<sup>237</sup> Np	1.99E-05	
<sup>95</sup> Mo	4.24E-05	<sup>95</sup> Mo	6.52E-05	
<sup>99</sup> Tc	4.08E-05	<sup>99</sup> Tc	6.26E-05	
<sup>101</sup> Ru	3.80E-05	<sup>101</sup> Ru	6.24E-05	
<sup>103</sup> Rh	2.30E-05	<sup>103</sup> Rh	3.36E-05	
<sup>109</sup> Ag	3.09E-06	<sup>109</sup> Ag	6.25E-06	
<sup>133</sup> Cs	4.45E-05	<sup>133</sup> Cs	6.77E-05	
<sup>147</sup> Sm	7.95E-06	$^{147}$ Sm	9.90E-06	
<sup>149</sup> Sm	1.99E-07	$^{149}$ Sm	1.96E-07	
<sup>150</sup> Sm	1.03E-05	$^{150}$ Sm	1.72E-05	
<sup>151</sup> Sm	6.57E-07	$^{151}$ Sm	7.95E-07	
<sup>152</sup> Sm	4.11E-06	<sup>152</sup> Sm	6.33E-06	
<sup>143</sup> Nd	3.31E-05	<sup>143</sup> Nd	4.45E-05	
<sup>145</sup> Nd	2.49E-05	<sup>145</sup> Nd	3.74E-05	
<sup>153</sup> Eu	3.17E-06	<sup>153</sup> Eu	5.99E-06	
<sup>155</sup> Gd	2.14E-07	<sup>155</sup> Gd	5.31E-07	
<sup>16</sup> O	4.62E-02	$^{16}$ O	4.62E-02	

# Axially averaged burn-up cases (A and C)

Average BU	Average BU = 30 GWd/t		Average B	BU = 30  GWd/t	Average $BU = 30 \text{ GWd/t}$		
5 years cooling time			5 years cooling time Locations 2 & 8 (14.04 GWd/t)		5 years o	cooling time $7(18,01,CWd/t)$	
	7 27E 06			7 12E 06		6 79E 06	
235 <sub>1</sub>	7.27E-00		235 I I	7.12E-06	235 <sub>1 1</sub>	0.78E-00	
236 <sub>1</sub> I	7.47E-04		236 <b>T</b> I	7.11E-04	236 <sub>1 1</sub>	0.55E-04	
238 <sub>1 1</sub>	0.32E-03		238 <sub>1 1</sub>	0.97E-03	238 <sub>1 1</sub>	8.55E-05	
<sup>238</sup> Du	2.19E-02		<sup>238</sup> Du	2.18E-02	<sup>238</sup> Du	2.18E-02	
<sup>239</sup> Du	2.79E-07		<sup>239</sup> Du	5.83E-07	<sup>239</sup> Du	7.18E-07	
<sup>240</sup> <b>D</b> u	9.32E-03		240 <b>Du</b>	1.01E-04	240 <b>Du</b>	1.10E-04	
Pu 241 <b>D</b> -	1.29E-03		Pu 241 <b>D</b>	1.33E-03	241 D	2.12E-03	
Pu 242D	5.14E-06		Pu 242 <b>D</b> -	6.59E-06	Pu 242 D	1.02E-05	
Pu 241 A	4.29E-07		241 A	6.43E-07	Pu 241 •	1.36E-06	
Am 243 <b>A</b>	1.46E-06		Am 243 <b>A</b>	1.89E-06	Am 243 •	2.98E-06	
237 <b>x</b>	2.91E-08		237 <b>x</b>	4.86E-08	237 <b>x</b>	1.29E-07	
<sup>95</sup> Np	3.11E-06		<sup>95</sup> Np	3.73E-06	95 r	5.29E-06	
<sup>29</sup> Mo	1.8/E-05		<sup>29</sup> Mo	2.12E-05	<sup>99</sup> M0	2.67E-05	
	1.79E-05		<sup>101</sup> D	2.03E-05	101p	2.57E-05	
	1.57E-05		<sup>101</sup> Ru	1.79E-05	<sup>101</sup> Ru	2.30E-05	
<sup>105</sup> Rh	1.02E-05		<sup>105</sup> Rh	1.16E-05	<sup>105</sup> Rh	1.46E-05	
<sup>109</sup> Ag	7.91E-07		<sup>109</sup> Ag	9.71E-07	<sup>109</sup> Ag	1.43E-06	
<sup>133</sup> Cs	1.97E-05		<sup>133</sup> Cs	2.22E-05	<sup>133</sup> Cs	2.81E-05	
<sup>147</sup> Sm	4.22E-06		<sup>147</sup> Sm	4.68E-06	<sup>147</sup> Sm	5.67E-06	
<sup>149</sup> Sm	1.74E-07		<sup>149</sup> Sm	1.80E-07	<sup>149</sup> Sm	1.89E-07	
$^{150}$ Sm	3.73E-06		<sup>150</sup> Sm	4.33E-06	<sup>150</sup> Sm	5.78E-06	
<sup>151</sup> Sm	4.62E-07		<sup>151</sup> Sm	4.86E-07	<sup>151</sup> Sm	5.36E-07	
<sup>152</sup> Sm	1.69E-06		<sup>152</sup> Sm	1.95E-06	$^{152}$ Sm	2.52E-06	
<sup>143</sup> Nd	1.61E-05		<sup>143</sup> Nd	1.80E-05	<sup>143</sup> Nd	2.23E-05	
<sup>145</sup> Nd	1.12E-05		<sup>145</sup> Nd	1.26E-05	<sup>145</sup> Nd	1.58E-05	
<sup>153</sup> Eu	9.01E-07		<sup>153</sup> Eu	1.08E-06	<sup>153</sup> Eu	1.55E-06	
<sup>155</sup> Gd	5.43E-08		<sup>155</sup> Gd	6.38E-08	<sup>155</sup> Gd	9.02E-08	
<sup>16</sup> O	4.62E-02		<sup>16</sup> O	4.62E-02	<sup>16</sup> O	4.62E-02	

# Axially distributed burn-up cases (Case B)

Average B	Average BU = 30 GWd/t		
5 years of	5 years	cooling time	
Locations 4 &	Location 5	5 (32.86 GWd/t)	
<sup>234</sup> U	6.29E-06	<sup>234</sup> U	5.62E-06
<sup>235</sup> U	5.26E-04	<sup>235</sup> U	3.93E-04
<sup>236</sup> U	1.02E-04	<sup>236</sup> U	1.22E-04
<sup>238</sup> U	2.17E-02	<sup>238</sup> U	2.15E-02
<sup>238</sup> Pu	1.49E-06	<sup>238</sup> Pu	3.26E-06
<sup>239</sup> Pu	1.32E-04	<sup>239</sup> Pu	1.45E-04
<sup>240</sup> Pu	2.99E-05	<sup>240</sup> Pu	4.22E-05
<sup>241</sup> Pu	1.59E-05	<sup>241</sup> Pu	2.37E-05
<sup>242</sup> Pu	3.03E-06	<sup>242</sup> Pu	6.73E-06
<sup>241</sup> Am	4.76E-06	<sup>241</sup> Am	7.27E-06
<sup>243</sup> Am	3.97E-07	<sup>243</sup> Am	1.25E-06
<sup>237</sup> Np	7.90E-06	<sup>237</sup> Np	1.20E-05
<sup>95</sup> Mo	3.48E-05	<sup>95</sup> Mo	4.59E-05
<sup>99</sup> Tc	3.34E-05	<sup>99</sup> Tc	4.42E-05
$^{101}$ Ru	3.05E-05	<sup>101</sup> Ru	4.16E-05
$^{103}$ Rh	1.90E-05	<sup>103</sup> Rh	2.48E-05
<sup>109</sup> Ag	2.22E-06	<sup>109</sup> Ag	3.52E-06
<sup>133</sup> Cs	3.65E-05	<sup>133</sup> Cs	4.81E-05
<sup>147</sup> Sm	6.93E-06	<sup>147</sup> Sm	8.35E-06
<sup>149</sup> Sm	1.96E-07	<sup>149</sup> Sm	2.00E-07
<sup>150</sup> Sm	8.04E-06	<sup>150</sup> Sm	1.13E-05
<sup>151</sup> Sm	6.01E-07	<sup>151</sup> Sm	6.81E-07
<sup>152</sup> Sm	3.35E-06	<sup>152</sup> Sm	4.46E-06
<sup>143</sup> Nd	2.81E-05	<sup>143</sup> Nd	3.52E-05
<sup>145</sup> Nd	2.05E-05	<sup>145</sup> Nd	2.68E-05
<sup>153</sup> Eu	2.33E-06	<sup>153</sup> Eu	3.58E-06
<sup>155</sup> Gd	1.44E-07	<sup>155</sup> Gd	2.53E-07
<sup>16</sup> O	4.62E-02	<sup>16</sup> O	4.62E-02

Axially distributed burn-ups (Case B)

Average B	Average $BU = 50 \text{ GWd/t}$		Average E	BU = 50  GWd/t	Average $BU = 50 \text{ GWd/t}$		
5 years cooling time			5 years cooling time			5 years cooling time	
Locations 1 &	9 (21.56 GWd/t)		Locations 2 &	2 8 (24.02 GWd/t)		Locations 3 &	7 (30.58 GWd/t)
<sup>234</sup> U	6.49E-06		<sup>234</sup> U	6.29E-06		<sup>234</sup> U	5.79E-06
<sup>235</sup> U	5.68E-04		<sup>235</sup> U	5.26E-04		<sup>235</sup> U	4.25E-04
<sup>236</sup> U	9.46E-05		<sup>236</sup> U	1.02E-04		<sup>236</sup> U	1.18E-04
<sup>238</sup> U	2.17E-02		<sup>238</sup> U	2.17E-02		<sup>238</sup> U	2.16E-02
<sup>238</sup> Pu	1.13E-06		<sup>238</sup> Pu	1.49E-06		<sup>238</sup> Pu	2.73E-06
<sup>239</sup> Pu	1.26E-04		<sup>239</sup> Pu	1.32E-04		<sup>239</sup> Pu	1.42E-04
<sup>240</sup> Pu	2.64E-05		<sup>240</sup> Pu	3.00E-05		<sup>240</sup> Pu	3.91E-05
<sup>241</sup> Pu	1.36E-05		<sup>241</sup> Pu	1.60E-05		<sup>241</sup> Pu	2.19E-05
<sup>242</sup> Pu	2.26E-06		<sup>242</sup> Pu	3.03E-06		<sup>242</sup> Pu	5.65E-06
<sup>241</sup> Am	4.03E-06		<sup>241</sup> Am	4.76E-06		<sup>241</sup> Am	6.66E-06
<sup>243</sup> Am	2.62E-07		<sup>243</sup> Am	3.98E-07		<sup>243</sup> Am	9.74E-07
<sup>237</sup> Np	6.81E-06		<sup>237</sup> Np	7.90E-06		<sup>237</sup> Np	1.09E-05
<sup>95</sup> Mo	3.15E-05		<sup>95</sup> Mo	3.48E-05		<sup>95</sup> Mo	4.31E-05
<sup>99</sup> Tc	3.03E-05		<sup>99</sup> Tc	3.35E-05		<sup>99</sup> Tc	4.15E-05
<sup>101</sup> Ru	2.75E-05		$^{101}$ Ru	3.05E-05		<sup>101</sup> Ru	3.88E-05
<sup>103</sup> Rh	1.73E-05		$^{103}$ Rh	1.90E-05		$^{103}$ Rh	2.34E-05
<sup>109</sup> Ag	1.89E-06		<sup>109</sup> Ag	2.22E-06		<sup>109</sup> Ag	3.18E-06
<sup>133</sup> Cs	3.31E-05		<sup>133</sup> Cs	3.65E-05		<sup>133</sup> Cs	4.53E-05
<sup>147</sup> Sm	6.45E-06		<sup>147</sup> Sm	6.93E-06		$^{147}$ Sm	8.03E-06
<sup>149</sup> Sm	1.94E-07		<sup>149</sup> Sm	1.96E-07		<sup>149</sup> Sm	1.99E-07
$^{150}$ Sm	7.12E-06		<sup>150</sup> Sm	8.05E-06		<sup>150</sup> Sm	1.05E-05
<sup>151</sup> Sm	5.75E-07		<sup>151</sup> Sm	6.01E-07		<sup>151</sup> Sm	6.62E-07
<sup>152</sup> Sm	3.02E-06		<sup>152</sup> Sm	3.35E-06		<sup>152</sup> Sm	4.18E-06
<sup>143</sup> Nd	2.58E-05		<sup>143</sup> Nd	2.81E-05		<sup>143</sup> Nd	3.35E-05
<sup>145</sup> Nd	1.86E-05		<sup>145</sup> Nd	2.05E-05		<sup>145</sup> Nd	2.53E-05
<sup>153</sup> Eu	2.00E-06		<sup>153</sup> Eu	2.33E-06		<sup>153</sup> Eu	3.25E-06
<sup>155</sup> Gd	1.20E-07		<sup>155</sup> Gd	1.44E-07		<sup>155</sup> Gd	2.22E-07
<sup>16</sup> O	4.62E-02		<sup>16</sup> O	4.62E-02		<sup>16</sup> O	4.62E-02

# Axially distributed burn-up cases (Case D)

Average B	Average $BU = 50 \text{ GWd/t}$		
5 years of	cooling time	5 years	cooling time
Locations 4 &	Location 5	5 (54.60 GWd/t)	
<sup>234</sup> U	5.12E-06	<sup>234</sup> U	4.33E-06
<sup>235</sup> U	3.00E-04	<sup>235</sup> U	1.71E-04
<sup>236</sup> U	1.35E-04	<sup>236</sup> U	1.49E-04
<sup>238</sup> U	2.14E-02	<sup>238</sup> U	2.11E-02
<sup>238</sup> Pu	5.37E-06	<sup>238</sup> Pu	1.05E-05
<sup>239</sup> Pu	1.51E-04	<sup>239</sup> Pu	1.53E-04
<sup>240</sup> Pu	5.15E-05	<sup>240</sup> Pu	6.55E-05
<sup>241</sup> Pu	2.92E-05	<sup>241</sup> Pu	3.60E-05
<sup>242</sup> Pu	1.09E-05	<sup>242</sup> Pu	2.03E-05
<sup>241</sup> Am	9.09E-06	<sup>241</sup> Am	1.14E-05
<sup>243</sup> Am	2.51E-06	<sup>243</sup> Am	6.16E-06
<sup>237</sup> Np	1.56E-05	<sup>237</sup> Np	2.18E-05
<sup>95</sup> Mo	5.48E-05	<sup>95</sup> Mo	6.99E-05
<sup>99</sup> Tc	5.27E-05	<sup>99</sup> Tc	6.70E-05
<sup>101</sup> Ru	5.09E-05	$^{101}$ Ru	6.79E-05
<sup>103</sup> Rh	2.91E-05	$^{103}$ Rh	3.54E-05
<sup>109</sup> Ag	4.71E-06	<sup>109</sup> Ag	6.98E-06
<sup>133</sup> Cs	5.73E-05	<sup>133</sup> Cs	7.23E-05
<sup>147</sup> Sm	9.21E-06	$^{147}$ Sm	1.01E-05
<sup>149</sup> Sm	2.00E-07	<sup>149</sup> Sm	1.93E-07
<sup>150</sup> Sm	1.40E-05	$^{150}$ Sm	1.86E-05
<sup>151</sup> Sm	7.38E-07	<sup>151</sup> Sm	8.18E-07
<sup>152</sup> Sm	5.33E-06	<sup>152</sup> Sm	6.76E-06
<sup>143</sup> Nd	4.00E-05	<sup>143</sup> Nd	4.60E-05
<sup>145</sup> Nd	3.18E-05	<sup>145</sup> Nd	3.99E-05
<sup>153</sup> Eu	4.67E-06	<sup>153</sup> Eu	6.59E-06
<sup>155</sup> Gd	3.69E-07	<sup>155</sup> Gd	6.09E-07
<sup>16</sup> O	4.62E-02	<sup>16</sup> O	4.62E-02

Axially distributed burn-up cases (Case D)

### **APPENDIX 3**

#### Participants and analysis methods

#### (1) ABB, Sweden

Institute:ABB Atom, Nuclear Fuel Division (BRM), SwedenParticipants:Peter Hoglund, Waldemar LipiecComputer codes:PHOENIX4/KENO-VaData library:PHOENIX LIBRARY: 17 May 1994 (ENDF/B-VI based)No. of neutron energy groups:89 neutron energy groups

#### Comments:

The ABB standard code system for criticality calculations has been used in the analysis. It consists of a 2-D lattice code PHOENIX (collision probability with current coupling and final treatment by the S4 method) and the 3-D Monte Carlo code KENO-V.a. The final geometry of the 3-D system has been modelled in KENO. PHOENIX was used for local calculations to homogenise fuel assemblies and condense the cross-sections to 13 groups. Two types of assemblies have been distinguished: 13 in central positions and 8 in the corners. The resulting P0 transport corrected cross-sections for these two assembly types (for Cases B and D also combined with five axial regions) were used in the KENO calculations. The number of neutron histories was more than 650 000 for each case. Cases D and E converged slower and have a bit larger standard deviation.

#### (2) BfS-IKE, Germany

Institute: Bundesamt für Strahlenschutz (BfS), Salzgittzer, and Institut für Kernenergetik und Energiesysteme (IKE), Stuttgart, Germany
Participants: H.-H. Schweer (BfS), W. Bernnat (IKE)
Computer codes: CGM Code, developed at IKE and Monte Carlo Code MORSE-K
Data library: Based on JEF-1 data
No. of neutron energy groups: 242 for CGM and 60 for MORSE-K

#### Additional assumptions:

For the cladding material in the fuel region Cr and Fe were omitted.

#### (3) BNFL, UK

Company:	British Nuclear Fuels plc, Risley, Warrington, England
Participants:	Peter Rex Thorne and Russel Bowden
Computer codes:	MONK6B Monte Carlo method, using Superhistory powering
Data library:	MONK6B 8220 Point Energy Library, derived from UKNDL and JEF-2
No. of neutron en	ergy groups: Continuous energy

#### Comments:

MONK6B on Research Machines 486/20 SystemBase 25, operating under SCO UNIX System 5 Release 3.2.2.

3-D modelling of requested system.

No nuclides omitted from requested calculations. No convergence limit set on eigenvalue. Calculations performed using 20 stages of 1000 source neutrons per stage. Typical eigenvalue uncertainty on individual calculations of the order of 0.0018. Combined results show mean uncertainty of the order of 0.0010. It should be noted that the fission density distributions presented above combine the relative fission densities of the corresponding axial regions at each end of the fuel, due to limitations in running MONK6B calculations on the current computer system with the extended UKNDL/JEF-2 nuclear data library and the large number of materials, each containing a large number of nuclides. Analysis of the fission density results in nine axial zones should therefore, as a first approximation, assume symmetry of the fission density distribution about the central axial region.

#### (4) CEA, France

Institute:	CEA-SACLAY DMT/SERMA/LEPP, France			
Participants:	Y.K. Lee, C. Diop			
Computer codes:	APOLLO2 + TRIMARAN2 (cf: ICNC'95, pp. 3.12)			
Data library:	CEA93 (derived from JEF2.2)			
No. of neutron energy groups: 99				

#### (5) CSN, Spain

Institute:	Consejo de Seguridad Nuclear (CSN), Spain
Participants:	Jose M. Conde, Manuel Recio
Computer codes:	CASMO-3 v. 4.7 and SIMULATE-3P v. 4.02
Data library:	E4LTJB7, based primarily on ENDF/B-4, although some data come from ENDF/B-5
	and JEF-2, processed with NJOY
No. of neutron er	ergy groups: 70; the group structure is similar to that of WIMS with the addition of

one boundary at 1.855 eV

#### Additional assumptions:

The absorber nuclides <sup>95</sup>Mo, <sup>99</sup>Tc and <sup>101</sup>Ru are not included in the data library. Cross-sections for each fuel segment under storage conditions have been calculated using the CASMO storage rack option. Cross-sections for both the axial and radial reflectors have been obtained using the CASMO reflector model. A model has been set up for SIMULATE including 73 axial nodes, 5 cm high. Each fuel element has been modelled using  $2\times2$  radial nodes. Three different radial reflectors have been used, depending on the water thickness between the storage position and the cask wall. The axial reflectors in the model are shorter than in the Benchmark specification. It has been verified that both this difference and the active length difference (365 cm instead of 365.7 cm) have a negligible impact on the results.

#### (6) EMS, Sweden

Company:E Mennerdahl Systems (EMS)Participants:Dennis MennerdahlComputer codes:SCALE 4.1Data library:Burn-up library 27BURN-UPLIBNo. of neutron energy groups:27

#### Comments:

The number of neutron histories used for fresh fuel and flat axial burn-up profile was 100 000; the number of neutron histories for realistic axial burn-up profile was 700 000. Fission densities are not calculated accurately and should not be trusted, as they are useful only to the person making the

calculation (the code system has not been designed and validated for calculation of fission densities). Neutrons started in all fissile material for all problems. Fission densities are calculated as double integral (volume and energy) of fissions in one zone divided by the volume of that zone. The normalised data is the fission density of one zone divided by the sum of the fission densities of all zones. The formula given in the hand written specifications seems to concern fissions per region.

#### (7) GRS, Germany

Institute:Gesellschaft für Anlagen und Reaktorsicherheit (GRS) 85748 Garching, GermanyParticipants:B. Gmal, E.F. Moser, W. WeberComputer codes:SCALE-4Data library:Depletion library 27BURNUPLIBNo. of neutron energy groups:27

#### Comments:

Number of neutron histories: 300 000 (500 batches a 600 neutrons). Code sequences: CSAS2X, KENO-V.a for flat burn-up distribution, CSASIX, WAX, KENO-V.a for burn-up profile.

#### (8) IPSN, France

Institute:Institut de Protection et de Sûreté Nucléaire (France)Participants:G. Poullot, A. NouriComputer codes:APOLLO-1 (collision probability method, self-shielding)<br/>MORET-3 (Monte Carlo)Data library:CEA86 (based on JEF-1, ENDF/B4 ENDF/B5 and internal evaluations)No. of neutron energy groups: 99 for APOLLO-1 and 16 for MORET-3

#### (9) JAERI, Japan

Institute:	Fuel Cycle Safety Evaluation Laboratory, JAERI Japan	
Participants:	Kenya Suyama	
Computer codes:	MCNP4A	
Data library:	JENDL-3.2 library (FSXLIB-J3R2) at 300 K	
No. of neutron energy groups: Continuous		

#### (10) JINS-1, Japan

Institute:Institute of Nuclear Safety, NUPECParticipants:Susumu Mitake (INS) and Osamu Sato (MRI)Computer codes:MGCL-JINS; resonance self-shielding correction: BondarenkoData library:ENDF/B-IV (JENDL-3.2 for FP nuclides)No. of neutron energy groups:137

#### (11) JINS-2, Japan

Institute:Institute of Nuclear Safety, NUPECParticipants:Susumu Mitake (INS) and Osamu Sato (MRI)Computer codes:SCALE; resonance self-shielding correction: NordheimData library:ENDF/B4No. of neutron energy groups: 27

#### Comments for (10) and (11):

Code for k-effective calculation: KENO-V.a. Geometry modelling: Fuel pellets, clads and moderators are modelled individually based on their configurations and dimensions described

in NEA/NSC/DOC(94)25 (19 May 1994). No smeared technique is applied. Also referred is EMS/FO/95-07 prepared by D. Mennerdahl (13 Oct 95). Monte Carlo parameters (for all cases): No. of generations: 403, No. of initially skipped generations: 3, No. of histories/generation: 2400, Total no. of histories: 960 000.

#### (12) ORNL, USA

Institute:	Oak Ridge National Laboratory			
Participants:	M.D. DeHart, C.V. Parks			
Codes used:	SCALE-4.3 CSAS25 sequence for no axial distributions; Multiple CSASN			
	sequences + standalone KENO-V.a calculation for cases with axial distributions			
Data library:	SCALE 44GROUPNDF5 (44-group, ENDF/B-V) library			

#### Additional assumptions:

Resonance corrected cross-sections for all but seven actinides were calculated based on Region 5 (centre) conditions. ORNL's experience has shown that resonance processing is sensitive to burn-up only for <sup>234</sup>U, <sup>235</sup>U, <sup>236</sup>U, <sup>238</sup>U, <sup>239</sup>Pu, <sup>240</sup>Pu, and <sup>241</sup>Pu. Other nuclides have too little net worth or are too diluted to be sensitive to burn-up. Resonance corrections were calculated as a function of axial location (i.e. burn-up) only for these seven nuclides.

### (13) PNC, Japan

Institute:PNC Tokai WorksParticipants:Ichiro NojiriComputer codes:SCALE-4.2 (CSASIX – WAX – KENO V.a)Data library:BURNUP library for SCALE-4.2: 27BURNUPLIB (ENDF-B/IV and V)No. of neutron energy groups: 27Neutron data processing code or method: BONAMI-S , NITAWL-IIGeometry modelling: 3-DEmployed convergence limit or statistical errors for eigenvalues: 0.0010

### (14) UKDOT, UK

No. of neutron en	nergy groups:
Institute:	United Kingdom Department of Transport
Participant:	Jim Stewart
Computer code:	MONK6B (SCO UNIX PC VERSION - SCO7)
Data library:	MONK- 8220 point energy library (MONK6 library with added fission products)
No. of groups:	Continuous
Geometry:	3-D model
Convergence:	Typical standard deviation on keff about 0.0008

### **APPENDIX 4**

Additional accident configurations

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#### EMS/FO/95-07

### **BURN-UP CREDIT BENCHMARK PROBLEMS:** FLAT OR REALISTIC AXIAL PROFILES?

Dennis Mennerdahl October 13, 1995



Contribution to Phase II-B of a study by the OECD/NEA Working Group on Burn-up Credit in Criticality Safety

Sponsored by the Swedish Nuclear Power Inspectorate

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### BURN-UP CREDIT BENCHMARK PROBLEMS: FLAT OR REALISTIC AXIAL PROFILES?

### 1. Introduction

This paper contains specifications for two benchmark problems, in addition to the nine benchmark problems selected for Phase II-B by the OECD/NEA Working Group on Burn-up Credit. Comments to the additional proposals are also given.

### 2. Benchmark problem specifications

The isotopics and geometry of Problems A and B of Phase II-B are used. The only change is that the boron steel of the top 20 cm of fuel and above is replaced with water (see figure). This is a slight modification to the previous (incomplete) proposal.

- *Requested information:* K<sub>eff</sub> and standard deviation (for Monte Carlo methods).
- *Optional:* Neutron source distribution, normalised fission densities, results without fission products.



# Phase IIB cases Cases X1 and X2
- **Problem X1**. Flat burn-up profile as in Problem A of Phase II-B. Burn-up 30 GWd/tU and cooling time five years. Includes fission products.
- **Problem X2**. A more realistic axial burn-up profile as in Problem B of Phase II-B. Burn-up 30 GWd/tU and cooling time five years. Includes fission products.

#### 3. Preliminary results

Problem	K <sub>eff</sub>	σ
X1	0.9274	0.0012
X2	1.0040	0.0012
Δk	0.0766	0.0017

Problem	K <sub>eff</sub>	σ
А	0.8900	0.0020
В	0.8900	0.0008
Δk	0.0000	0.0022

#### 4. Problem discussion

Criticality safety is often summarised as a requirement for the neutron multiplication factor to be less than 1.00 with some margin.

Neutron multiplication factor =  $\frac{production \ factor}{absorption \ term + leakage \ term}$ 

The production factor takes into account neutron physics properties of the fissile material. This material includes actinides and fission products. The absorption term as used here includes effects of the materials between the fuel rods and assemblies but not absorbing materials between the major reflector materials and the fuel assemblies. The leakage term is defined as the combined effects of leakage from the outside reflector material, of absorption in the materials surrounding the fuel array and of changes in the energy spectrum, geometry and direction of returning neutrons.

The purpose of Phase II, as I understand it, is to study the influence of axial variations and to discuss possible approximations, in particular assuming a flat axial burn-up profile. A flat burn-up profile based on fresh fuel is one extreme. A flat burn-up profile based on an average burn-up for the whole assembly is the other extreme. A correct solution must take the real axial burn-up profile into account.

Phase II-A includes two parameters that vary axially, total burn-up and cooling time. Both are related to the "production factor" in the ratio defined above. Unfortunately, Phase II-B does not add any parameters.

The two additional benchmark problems that have been proposed earlier and are specified here, add axial variations to both the "absorption term" and to the "leakage term". The boron steel acts both as an "internal absorber" of neutrons travelling between fuel assemblies and as a "reflector absorber" to reduce the number of neutrons that are reflected.

The benchmark problems defined here may not be directly related to a realistic incident for the transport cask selected for Phase II-B. For spent fuel pools, similar effects have been identified and analysed, with credit taken for burn-up. In the USA, up to 10 cm "gaps" have been observed in absorber materials. In Sweden, 60 cm "overlaps" (no water separation as opposed to the normal 10 cm separation) between stored fuel and fuel being handled were considered possible events for PWR and BWR spent fuel.

There are other ways to let the leakage term vary axially. One way would be to let a good reflector material closely surround the fuel region at the top, while the central region is surrounded by a poor reflector. Using a cask design where leakage is more important is another option. However, the purpose of this paper is not to maximise the theoretical impact of axial variations, but to define some useful benchmark specifications and to encourage further studies.

### 5. Background

The benchmark problems selected in the Phases II-A and II-B are typical for simple design calculations. However, they are not representative of some of the more complicated situations that are identified and analysed in safety assessments and in incidents that were not analysed at all. An explanation could be that the majority of the Working Group either has specific interests (nothing wrong with that – it is often such interests that lead to major contributions to safety) that are covered by the existing benchmark problems or has little interest in burn-up credit.

For those of us who are interested in and feel responsible for criticality safety in general, there are reasons for concern. A flat axial burn-up profile is a very crude approximation and before we support its use, we should understand its limitations. It is also important to have adequate methods and training to handle the situations when the approximation is not adequate.

The Working Group is involved in testing and comparing calculation methods. Are these capable of solving problems related to burn-up credit correctly? So far, we don't know. The Phase II-A and II-B results have caused some of us to believe that the flat profile approximation is acceptable for burn-ups less than 50 GWd/tU and cooling times shorter than five years. Even for that high burn-up and cooling time, the effect on k<sub>eff</sub> only seems to be 3-4%. Generalised conclusions like these are dangerous. At least one paper at the ICNC'95 conference referred to such preliminary results of the Working Group.

### 6. Motivation for "a deeper understanding"

In Sweden, there are currently no immediate requests for burn-up credit. Several years ago, the issue was seriously studied in connection with the design of compact storage modules for PWR and BWR spent fuel at the large central facility in Sweden (CLAB). A result of the study was that burn-up credit was possible, but that the combined effect of administrative and technical controls, uncertainties and probable delays was not worth the effort. Large amounts of boron steel were used instead.

Spent fuel is shipped in Sweden, usually using package designs from other states. The authorities should be prepared for dealing with requests for burn-up credit if this is practised in other parts of the world.

However, the most important reason for evaluating burn-up credit is probably the need to be able to estimate the real safety margin. This can be very important in case of an incident.

One scenario is that the experts, based on the flat profile approximation, conclude that criticality cannot occur. Then, during recovery operations, there is a criticality accident.

Another scenario is that the experts, knowing that burn-up credit can be complicated but not being prepared for it, make a conservative (pessimistic) assumption and recommend the surrounding population to be evacuated. Such an operation could lead to very severe consequences in many ways.

Fast and proper evaluation of incidents may save lives, property and other resources, reduce stress (panic) in the population and increase the trust in the nuclear industry and authorities. Conservative assumptions (fresh fuel) in the case of an incident could lead to much more severe consequences than even a criticality accident.

### 7. Conclusions related to general criticality safety

In Phases II-A and II-B, we have shown that scenarios exist where the flat axial burn-up profile approximation appear acceptable for burn-ups not exceeding 30 GWd/tU and cooling times not exceeding five years. However, we have also recognised that with realistic axial burn-up profiles, the calculation problem is more complicated.

For burn-ups of about 50 GWd/tU and cooling times of up to five years, the flat axial burn-up profile approximation is non-conservative with a  $\Delta k_{eff}$  of about 0.03. In Monte Carlo methods, the number of neutrons that normally give "converging" statistics is no longer sufficient. The trend (bias) may be missed if the user is not aware of the problem. With deterministic methods, other complications have been noticed.

Phases II-A and II-B only deal with axial effects due to varying fissile material (neutron production factor). Axial effects due to variations in absorption and leakage are not included. Realistic applications and design basis incidents in transport, handling and storage of spent fuel often involve combinations of the three mentioned variations. Without studying such combinations, we will not know if our calculation methods are adequate.

To give some indication of the potential for a much higher  $\Delta k_{eff}$  than 0.03 even for the case of 30 GWd/tU, the additional problems X1 and X2 have been specified. These problems are not optimised, but chosen so that they are similar to the Phase II-B problems. The preliminary  $\Delta k_{eff}$ of 0.08 indicates that also for lower burn-ups than 30 GWd/tU, the flat axial burn-up profile approximation may not be adequate. The approximation has to be evaluated for each application and scenario.

# **APPENDIX 5**

## Supplementary study of convergence

Note by Susumu Mitake and Osamu Sato Institute of Nuclear Safety, NUPEC

## 1. Problem specification

The following documents were used:

- Agreed Modification of Problem II-B: NEA/NSC/DOC(95)15, Annex 3
- Proposed Spent Fuel Cask Geometry, OECD Phase II-B Benchmark: NEA/NSC/DOC(94)25
- Burn-up credit Axial effect Criticality safety: EMS/FO/94-04

# 2. Analysed cases

Including the cases proposed by Mennerdahl, eleven cases (A...E, and 6...11) were analysed.

Burn-up and cooling	Burn-up and cooling Axial distribution		Case ID
30 GWD/tU	No	Borated steel	A
5 years with fission products		with 20 cm water region with 10 cm water region	6 8
30 GWD/tU 5 years with fission products	Specified	Borated steel with 20 cm water region with 10 cm water region	B 7 9
50 GWD/tU 5 years with fission products	No	Borated steel Steel	C 10
50 GWD/tU 5 years with fission products	Specified	Borated steel Steel	D 11
Fresh fuel (4.5 wt% <sup>235</sup> U)	No	Borated steel	Е

## 3. Analytical method

For cases A to E, two neutron libraries, MGCL-JINS library and SCALE 27-group library, were comparatively used. And, for cases 6 to 11, only the former was used. The KENO-V.a code was used for the k-effective calculations.

- MGCL-JINS library Neutron cross-section: ENDF/B-IV (JENDL-3.2 data were adopted for fission product nuclides) No. of energy groups: 137 Resonance self-shielding correction: Bondarenko
- SCALE 27-Group library Neutron cross-section: ENDF/B-IV No. of energy groups: 27 Resonance self-shielding correction: Nordheim

## 4. Geometry modelling

Fuel pellets, clads and moderators were modeled individually based on their configurations and dimensions described in NEA/NSC/DOC(94)25. No smeared technique was applied, except for the End Hardware region. Volumetric fractions of steel and water were only specified for the region.

## 5. Monte Carlo parameters

No. of generations:	403
No. of initially skipped generations:	3
No. of histories/generation:	300
Total no. of histories:	120 000

## 6. Results

	With	MGCL-JINS library	With SCALE 27-G library			
	$\mathbf{k}_{\mathrm{eff}}$	Statistical error (1-sigma)	$\mathbf{k}_{\mathrm{eff}}$	Statistical error (1-sigma)		
А	0.83062	0.00177	0.82317	0.00164		
В	0.89978	0.00185	0.88727	0.00167		
С	0.76866	0.00162	0.75831	0.00149		
D	0.79806	0.00165	0.78460	0.00176		
E	1.13043	0.00186	1.11456	0.00194		

	With	With MGCL-JINS library						
	$\mathbf{k}_{\mathrm{eff}}$	Statistical error (1-sigma)						
6	0.9361	0.0019						
7	0.9361	0.0022						
8	0.8548	0.0017						
9	0.9747	0.0020						
10	0.8777	0.0016						
11	0.9053	0.0017						

### 7. Fission distribution

In the Monte Carlo simulation analysis, the number of fissions occurring in the top or bottom regions of fuel pins are calculated to be small, because the neutron importance of these regions are small compared to that of the central region. Therefore, large statistical deviations of fission rates result at the top or bottom regions. When it is required to evaluate the difference of the analytical results which are made with or without the axial burn-up profile, however, the accuracy of fission rates calculated in these regions may increase to play a more important role in defining the multiplication factor. So, we checked the fission rates and their statistical errors in each axial region of the fuel pins and the multiplication factors, varying the number of generations (GEN) and the number of histories per generation (NPG), as suggested by Mennerdahl. The results of these calculations for the E-compositions (fresh fuel) with the KENO-V.a code and the MGCL-JINS library are shown in Table AI.

The results with various GENs (from 103 to 3203) and a fixed NPG (300) are tabulated in the upper half of the table. The fission fraction of central region (Region 5) is as high as over 90%, and the contributions of the top and bottom regions (Regions 1, 2, 8 and 9) are only a few per cent. The fission fraction of Region 5 varies with the value of GEN, and does not converge even with increased generations. Deviation of the multiplication factors with the various GENs results to about 0.5% Dk/k.

The lower half of the table shows the results with various NPGs (from 300 to 4800) and a fixed GEN (203). The fission fractions in each axial region converge simply with increased histories, and differences of the fission fractions and the multiplication factors for the cases with NPG of 2400 and 4800 are as low as 0.001 and about 0.07% Dk/k, respectively. Thus, the NPG of 2400 is large enough for the present analysis with axial burn-up profile.

(Our results presented in § 6 had been obtained before the above discussions were made, so we had previously used an NPG of 300 and a GEN of 403.)

### 8. Comparison with Phase II-A

The reactivity change among these cases, which is evaluated with a formula (k-k')/kk' using k-effectives, was also analysed in the Phase II-A problem, an infinite array of fuel rods.

First, the reactivity decrease with burn-up are comparatively tabulated for the cases without axial burn-up distribution.

	30 GV	Vd/tU	50 GWd/tU			
	MGCL-JINS	SCALE 27G	MGCL-JINS	SCALE 27G		
Phase II-A (rod array)	-22.2%	-22.6%	-30.7%	-30.7%		
Phase II-B (cask)	-31.9%	-31.8%	-41.6%	-42.2%		

Greater reactivity decrease are found in the cases of Phase II-B which have a larger neutron leakage. It may be not easy to explain the physical meaning of these results simply based on the neutron balance concept.

	30 GV	Wd/tU	50 GWd/tU			
	MGCL-JINS	MGCL-JINS SCALE 27G MGCL-JIN		SCALE 27G		
Phase II-A (rod array)	+ 5.38%	+ 5.90%	+ 3.87%	+ 3.67%		
Phase II-B (cask)	+ 9.25%	+ 8.78%	+ 4.79%	+ 4.42%		

Second, the reactivity increases due to the effect of axial burn-up distribution are compared.

Reactivity change: [k(B)-k(A)]/k(B)k(A) or [k(D)-k(C)]/k(D)k(C)

The reactivity increases are significant for the cases of transport cask configuration in which a finite number of fuel rods are allocated.

NPG		300										
GEN	1	.03	203		403		803		1603		3203	
Ax. reg.	Fissions*	$\pm 1\sigma$	Fissions	$\pm 1\sigma$	Fissions	$\pm 1\sigma$	Fissions	$\pm 1\sigma$	Fissions	$\pm 1\sigma$	Fissions	$\pm 1\sigma$
1 (5cm)	0.0052	$\pm 11.24\%$	0.0015	$\pm$ 12.72%	0.0016	$\pm 8.45\%$	0.0019	$\pm 7.98\%$	0.0022	$\pm 5.85\%$	0.0027	$\pm 3.42\%$
2 (5cm)	0.0070	$\pm 9\%$	0.0020	$\pm\ 10.83\%$	0.0019	$\pm 8.06\%$	0.0022	$\pm$ 7.02%	0.0027	$\pm 5.14\%$	0.0035	$\pm 3.15\%$
3 (10cm)	0.0220	$\pm 6.44\%$	0.0072	$\pm 8.3\%$	0.0061	$\pm 5.51\%$	0.0065	$\pm 6.05\%$	0.0086	$\pm 4.46\%$	0.0104	$\pm 2.21\%$
4 (20cm)	0.0532	$\pm 5.6\%$	0.0243	$\pm 6\%$	0.0203	$\pm 3.85\%$	0.0189	$\pm 5.49\%$	0.0268	$\pm 3.38\%$	0.0339	$\pm 1.32\%$
5 (285.7cm)	0.8943	$\pm 0.66\%$	0.9196	$\pm 0.56\%$	0.9567	$\pm 0.26\%$	0.9439	$\pm 0.26\%$	0.9106	$\pm 0.21\%$	0.9086	$\pm 0.16\%$
6 (20cm)	0.0111	$\pm 9.93\%$	0.0304	$\pm 6.73\%$	0.0090	$\pm 6.34\%$	0.0186	$\pm 3.56\%$	0.0324	$\pm 2.14\%$	0.0271	$\pm 1.89\%$
7 (10cm)	0.0049	$\pm 13\%$	0.0101	$\pm 8.79\%$	0.0028	$\pm$ 7.92%	0.0050	$\pm 5.76\%$	0.0106	$\pm 2.69\%$	0.0086	$\pm 2.36\%$
8 (5cm)	0.0014	$\pm\ 17.65\%$	0.0027	$\pm\ 11.49\%$	0.0008	$\pm\ 12.86\%$	0.0016	$\pm 7.14\%$	0.0035	$\pm 3.58\%$	0.0030	$\pm 2.81\%$
9 (5cm)	0.0010	$\pm\ 19.37\%$	0.0021	$\pm 13.5\%$	0.0008	$\pm\ 12.82\%$	0.0013	$\pm 8.24\%$	0.0026	$\pm 4.03\%$	0.0023	$\pm 3.14\%$
$k_{eff}$	1.1300	$\pm 0.00406$	1.1287	$\pm 0.00282$	1.1283	$\pm 0.00207$	1.1249	$\pm 0.0016$	1.1244	$\pm 0.00101$	1.1249	$\pm 0.00072$

Table AI. Axial fission distributions and multiplication factors with various NPG and GEN (Case 5: fresh fuel)

NPG	300		6	00	1200		2400		4800	
GEN					2	203				
Ax. reg.	Fissions	$\pm 1\sigma$	Fissions	$\pm 1\sigma$	Fissions	$\pm 1\sigma$	Fissions	$\pm 1\sigma$	Fissions	$\pm 1\sigma$
1 (5cm)	0.0015	$\pm 12.72\%$	0.0014	$\pm 9.71\%$	0.0011	$\pm 7.96\%$	0.0016	$\pm 4.73\%$	0.0016	$\pm 3.6\%$
2 (5cm)	0.0020	$\pm\ 10.83\%$	0.0020	$\pm 8.81\%$	0.0014	$\pm 7.6\%$	0.0020	$\pm 4.27\%$	0.0021	$\pm 3.16\%$
3 (10cm)	0.0072	$\pm 8.3\%$	0.0068	$\pm 6.54\%$	0.0047	$\pm 5.69\%$	0.0064	$\pm 3.28\%$	0.0065	$\pm 2.49\%$
4 (20cm)	0.0243	$\pm 6\%$	0.0240	$\pm 4.87\%$	0.0174	$\pm 4.38\%$	0.0222	$\pm 2.48\%$	0.0226	$\pm 1.93\%$
5 (285.7cm)	0.9196	$\pm 0.56\%$	0.9308	$\pm 0.35\%$	0.9220	$\pm 0.26\%$	0.9260	$\pm 0.17\%$	0.9264	$\pm 0.12\%$
6 (20cm)	0.0304	$\pm 6.73\%$	0.0223	$\pm 5.07\%$	0.0377	$\pm 3.2\%$	0.0306	$\pm 2.4\%$	0.0293	$\pm 1.75\%$
7 (10cm)	0.0101	$\pm 8.79\%$	0.0079	$\pm 6.54\%$	0.0123	$\pm 3.83\%$	0.0098	$\pm 2.99\%$	0.0093	$\pm 2.26\%$
8 (5cm)	0.0027	$\pm 11.49\%$	0.0024	$\pm 7.86\%$	0.0039	$\pm 4.75\%$	0.0032	$\pm 3.67\%$	0.0030	$\pm 2.87\%$
9 (5cm)	0.0021	$\pm 13.5\%$	0.0017	$\pm 9.99\%$	0.0027	$\pm 5.67\%$	0.0023	$\pm 4.29\%$	0.0022	$\pm 3.18\%$
k <sub>eff</sub>	1.1287	$\pm 0.00282$	1.1275	$\pm 0.00199$	1.1289	$\pm 0.00142$	1.1291	$\pm 0.00099$	1.1283	$\pm 0.0007$

\* Fission distributions are calculated by KENO-V.a code with MGCL-JINS library, and the total fission is normalised to unity.

NPG: Number of histories/generation GEN: Number of generations