Meeting of WPEC Subgroup 46 on "Target Accuracy Requirements (TAR) for the SG46 Exercise"

Welcome and Meeting Objectives

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❑ WPEC/SG26 (2005-2008)

https://oecd-nea.org/download/wpec/volume26/volume26.pdf

- **Systems**

ABTR: 250 MWth	Na cooled
SFR: (Burner: CR=0.25) 840 MWth	Na cooled
EFR: 3600 MWth	Na cooled
GFR: 2400 MWth	He cooled
LFR: 900 MWth	Pb cooled
ADMAB: 377 MWth	Pb-Bi cooled
VHTR	TRISO fuel
Extended BU PWR	8.5wo%

- **Integral parameters**

Criticality (keff)	(in pcm)
Local Power Peak	(in %)
Burnup reactivity swing	(in pcm)
Reactivity coefficients	(in %)
Nuclide inventories/transmutation at EOL	(in %)

- A first list of data priorities (i.e. **for uncertainty reduction**) for GEN-IV reactors was established and implemented in the HPRL at NEA

Table 26. SFR: uncertainty reduction requirements needed to meet integral parameter target accuracies

Isotope	Cross-Section	Energy range	Uncertainty (%)			
			Initial	Required		
				$\lambda=1$	$\lambda\neq1$ [a]	$\lambda\neq1$ [b]
U238	σ_{capt}	24.8 - 9.12 keV	9	4	3	3
	σ_{inel}	6.07 - 0.498 MeV	20	5	6	10
Pu238	σ_{capt}	183 - 24.8 keV	20	12	12	10
	σ_{fiss}	6.07 – 0.09 MeV	20	3	3	3
	ν	1.35 - 0.067 MeV	7	3	3	2
Pu239	σ_{capt}	498 – 2.03 keV	12	6	4	4
	σ_{inel}	6.07 – 0.498 MeV	25	12	15	22

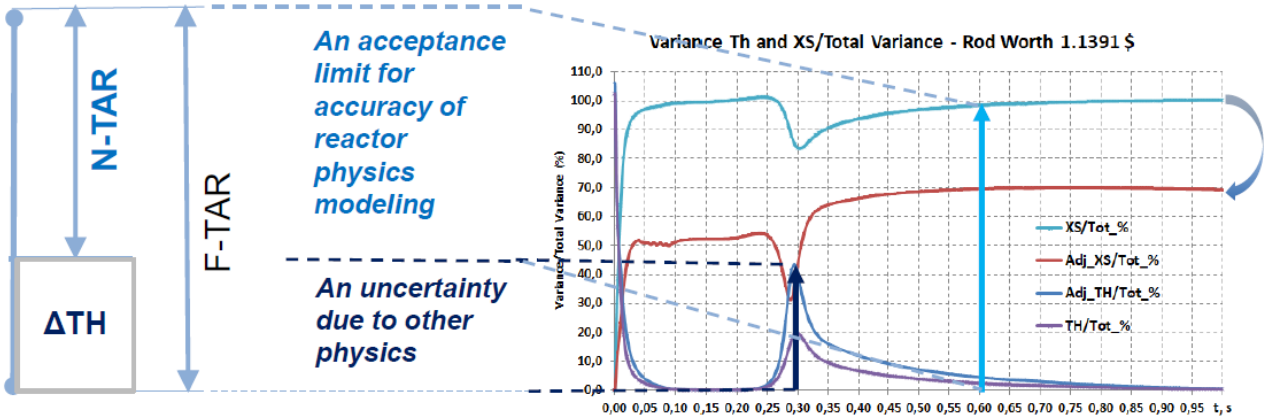
Table 32. Summary of Highest Priority Target Accuracies for Fast Reactors

		Energy Range	Current Accuracy (%)	Target Accuracy (%)
U238	σ_{inel}	6.07 ÷ 0.498 MeV	10 ÷ 20	2 ÷ 3
	σ_{capt}	24.8 ÷ 2.04 keV	3 ÷ 9	1.5 ÷ 2
Pu241	σ_{fiss}	1.35MeV ÷ 454 eV	8 ÷ 20	2 ÷ 3 (SFR,GFR, LFR) 5 ÷ 8 (ABTR, EFR)
Pu239	σ_{capt}	498 ÷ 2.04 keV	7 ÷ 15	4 ÷ 7
Pu240	σ_{fiss}	1.35 ÷ 0.498 MeV	6	1.5 ÷ 2
	ν	1.35 ÷ 0.498 MeV	4	1 ÷ 3

❑ Target Accuracy: *Necessity of "Expert Judgment"*

Target accuracy establishment for multi-physics processes

- Target Accuracy Requirements (TARs) represent wishes and acceptance limits established by designers and/or assessors
- Sg46 task => to establish TARs for Nuclear Data libraries
- One should separate (approximately) impacts due to reactor physics and due to other physics => combining sampling and linearized response (sensitivity) studies
- Sampling-based back-propagation with reduced (adjusted) ND uncertainties
- Note: practically used simulations (no exemptions) based on a hierarchic structure; we are following a kind of a gradient descent approach to quantify uncertainties of different nature



23 OECD-NEA/NSC/WPEC/SG46, NOVEMBER 11, 2020, WEBEX MEETING IRSN MEMBRE DE ETSON

by Evgeny Ivanov (WPEC/S46, Nov.2020)

WPEC/SG46 Exercise (2019-2021)

- WPEC/SG46 is the bridge between ND evaluators and end-users in the utilisation of integral experiments
- WPEC/SG46 to provide **updated target accuracies for nuclear data uncertainty reduction**
  - *"It is essential to **verify the status of design target accuracies** and their potential evolution (reactor operation and fuel cycle parameters)"*
  - *New reactors concepts are presently explored besides Gen IV, MA burners, and ADS: MSR, SMR, micro reactors, and test reactors*
- **WPEC/SG46 methodology** based on:
  - *New covariance data matrices: ENDF/B-VIII.0, JEFF-3.3, JENDL-4u/5, TENDL2019,…*
  - *Using cross-correlations in energy, reactions and isotopes*
  - *Energy structure: "7 energy groups (based on physical considerations)"*
- *"The **HPRL** will certainly benefit from an update, to motivate and focus new experiments and to meet potential new requirements"*

TAR via sensitivity analysis

The **“inverse problem”:**

- To define the TAR on design parameters
- To find out the required reduction in the cross section uncertainties

$$To\ minimize: \left(\sum_i \frac{\lambda_i}{x_i^2}\right) \quad i = 1, \dots, I$$

λ_i: cost parameter related with each cross−section

x_i: uncertainty cross−section (i.e. standard deviation)

I: total number of reactions-energy groups whose uncertainty is to be determined

ISOTOPES: ^{52}Cr, ^{56}Fe, ^{58}Ni, ^{235}U, ^{238}U, ^{239}Pu…. + coolant ,…others

REACTIONS: σ_{cap}, σ_{fiss},ν , σ_{el}, σ_{inel}, PFNS and elastic-μ,...

ENERGY Groups: 7

The objective function is constrained to:

1) $x_i \geq 0; i = 1 \dots I$

2) $\sum_i S_{ni}^2 \cdot x_i^2 + \sum_{ii'} S_{ni} \cdot x_i \cdot corr_{ii'} \cdot x_{i'} \; S_{ni}^+ \leq (R_n^T)^2; n = 1 \dots N$

S_{ni}: sensitivity coefficient for the integral parameter R_n

$corr_{ii'}$: correlation between i and i′

R_n^T : target accuracies on the N-integral parameters

WPEC/SG46: Selection of Target Systems

WPEC/SG26	ABTR: 250 MWth	Na cooled
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	EFR: 3600 MWth	Na cooled
	GFR: 2400 MWth	He cooled
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	VHTR	TRISO fuel
	Extended BU PWR	8.5wo%
WPEC/SG33	ABR (metal) ABR(oxide)	
	JOYO experimental fast reactor	
WPEC/SG46	**MYRRHA**	
	ALFRED	
	JSFR-750	
	Low sodium void SFR	
	SMR	
	MSR	
	etc…	

WPEC/SG46: Integral Parameters

WPEC/SG26	Criticality (keff)	(in pcm)
	Local Power Peak	(in %)
	Burnup reactivity swing	(in pcm)
	Reactivity coefficients	(in %)
	Nuclide inventories/transmutation at EOL	(in %)
WPEC/SG46	***Decay heat in a repository (e.g. at 100 years after disposal)**	**(in %)**
	***Radiotoxicity (e.g. t=100000 years after disposal)**	**(in %)**
	***Radiation source (e.g neutron emission) at fuel discharge and different cooling times**	**(in %)**

* M. Salvatores, Fuel cycle parameters from SG26: Choices and volunteers, WPEC/SG46 Nov. 2019

* N. García-Herranz et al., Nuclear data requirements for the ADS conceptual design EFIT: Uncertainty and sensitivity study. *Annals of Nuclear Energy 37 (2010) 1570–1579.*