

TARS from NEA activities Past and Present

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Division of Nuclear Science

WPEC SG46

November 25 2019

Overview

- TAR's
- Outreach
- Next Steps

Commercial Fast Reactor TARs (~1980)

NEA/RP-A-612

THE PRESENT ACCURACY OF PHYSICS CHARACTERISTICS
OF UNIRRADIATED FAST REACTOR CORES

by

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Institute for Neutron Physics and Reactor Technology

S. Pilate
Belgonucleaire, Brussels

- Large spread between countries for k_{eff}
- Haven't read the references

Table 1: Target Accuracies for a Commercial Fast Reactor (1-sigma level)

Parameter	DeBeNe(a) (/2/,1973)	France (/3/,1979)	Japan (/4,5/,1974)	United Kingdom (/5,6/,1978)	USA (/7,8/,1972)
k_{eff} (%)	0.8	0.15	0.9 - 1.2	0.5 - 1.0	0.6
Breeding Gain	0.02 - 0.03	0.015	0.02	0.02	0.02
Power (P) Distributions (%)	P_{max}/\bar{P} : 1.5	P_{max}/\bar{P} : 1.5	core: 1.5 blanket: 3.0	1.0	P_{max}/\bar{P} : 2.0

Adjustment Exercise ~1980

Commercial Fast Reactor Detailed unadjusted vs. adjusted

Table 3: Summary of One-Group-Averaged Cross Sections

Organization	k-infinity Inner Core	E(Phi) in keV	²³⁸ U Capture	²³⁸ U Fission	²³⁹ Pu Capture	²³⁹ Pu Fission	²³⁹ Pu Alpha	¹⁰ B Transport	Fe Transport	Na Transport	O Transport
Non-Adjusted Nuclear Data											
ANL	1.10850	107.720	0.30687	0.04031	0.56781	1.84297	0.30810	5.44836	4.01792	4.15189	3.53076
BELGIUM	1.09500	108.005	0.33170	0.04004	0.45194	1.82496	0.24764	---	4.71243	4.78848	3.74731
CNEN	1.14558	113.793	0.30250	0.04518	0.57407	1.87984	0.30538	5.40132	4.07896	4.10724	3.53955
EIR-1	1.10442	109.117	0.30448	0.03995	0.57734	1.87503	0.30791	5.46198	5.36215	4.54541	3.58767
EIR-2	1.11735	111.779	0.32230	0.04158	0.58030	1.92367	0.30166	5.48159	4.54193	4.36690	3.50487
HEDL	1.11870	---	---	---	---	---	---	---	---	---	---
JAERI-1	1.11710	108.758	0.30991	0.04457	0.60820	1.88247	0.32309	5.52344	4.79261	4.45146	3.51690
KARLSRUHE-1	1.11840	108.797	0.30858	0.04097	0.57101	1.87191	0.30504	---	3.12493	4.06499	3.34958
SWEDEN	1.08680	108.845	0.30856	0.03868	0.54087	1.88136	0.28749	5.47947	3.76949	4.18664	3.48434
USSR	1.13270	118.106	0.30915	0.04009	0.49816	1.76992	0.28146	5.35558	4.06790	4.29630	3.44045
Adjusted Nuclear Data											
CADARACHE-1	1.15242	117.996	0.29234	0.03867	0.56750	1.81550	0.31259	---	---	---	---
CADARACHE-2	---	---	0.29550	0.03919	0.57910	1.81625	0.31884	---	---	---	---
JAERI-2	1.13564	108.916	0.29624	0.04048	0.52881	1.84266	0.28698	5.51229	3.93776	4.14213	3.49352
JAERI-3	1.13189	101.988	0.30905	0.04381	0.58704	1.89176	0.31031	5.79390	3.97266	4.38019	3.50360
KARLSRUHE-2	1.14843	112.058	0.30406	0.04159	0.54816	1.86915	0.29328	---	3.85887	4.55270	3.54034
UKAEA	1.15123	111.991	0.29137	0.04302	0.54539	1.83265	0.29760	5.41029	3.53615	4.09901	3.31038
Mean	1.12428	110.562	0.30617	0.04121	0.55505	1.85467	0.29916	5.48682	4.13644	4.31794	3.50379
Std. Dev.	0.02054	4.213	0.01069	0.00207	0.03909	0.03889	0.01850	0.11979	0.58546	0.22086	0.10643

80s Requested Accuracy for Various Application

Q: Are previous requests relevant today?

- *New systems*
- *New nuclear data measurements*
- *New covariance data*
- Were previous needs addressed?
- Are some still relevant? Overlap between 'New' and 'Old' requests?

Fispin depletion calculations

17 JUL 1980

NEANDC(UK)174A
NEACRP-A-400
INDC(UK)-34/G

An Assessment of the Accuracy Requirements on Higher Actinide Nuclear Data for Fast Reactors

B.H. Patrick and M.G. Sowerby
Nuclear Physics Division, AERE, Harwell.

TABLE 16

Nuclear Data Requirements of Highest Priority

Quantity	Present Accuracy (%)	New Required Accuracy (%)	Purpose
Np-237 σ_{n2n}	100	25	Production of Pu-236
Am-241 σ_{ny}^g	20	8 10	Total heat generation Total neutron production
Am-243 σ_{ny}	25	10	Total neutron production
Cm-242 spontaneous fission branching ratio	10	5	Total neutron production
(α, n) yield	30	10*	Total neutron production

TABLE 17

Summary of Achieved Accuracies and Requirements

Quantity	Currently Requested Accuracy* (%)	Uncertainty Due to Errors in Actinide Data (%)	Most Important Data Needing Improvement to Achieve Higher Accuracy**
Production of Pu-236	100(2 σ)	100	Np-237 σ_{n2n} [100%]
Production of Pu-238	20	8.5	Am-241 σ_{ny}^g [6.5%], Pu-238 σ_{nf} [3.5%], Pu-238 σ_{ny} [3%]
Production of Am-241	100(2 σ)	6.3 - 4.4	Am-241 σ_{ny}^g [5%], Pu-241 $T_{1/2}$ [3%]
Production of Am-243	100(2 σ)	10	Pu-242 σ_{ny} [9.5%], Am-243 σ_{ny} [3.5%]
Production of Cm-242	100(2 σ)	17 - 13	Am-241 σ_{ny}^g [15%], Am-241 σ_{ny}^m [12%], Cm-242 σ_{nf} [5%]
Production of Cm-244	100(2 σ)	22	Am-243 σ_{ny} [19%], Pu-242 σ_{ny} [10%]
α -decay heat	$\alpha 5$	15 - 4	Am-241 σ_{ny}^g [13%], Cm-242 σ_{nf} [4%], Pu-241 $T_{1/2}$ [3%]
Total heat generation	5***	5.6 - 2.3****	Am-241 σ_{ny}^g [5%], Cm-242 σ_{nf} [1.5%]
Spontaneous fission neutrons		14 - 20	Am-241 σ_{ny}^g [10%], Am-243 σ_{ny} [10%], Pu-242 σ_{ny} [8%]
(α, n) neutrons		19 - 11	Am-241 σ_{ny}^g [14%], (α, n) yield [10%], Cm-242 σ_{nf} [4%]
Total neutron production 10 (reactivity) 20 (shielding)		14 - 20	Am-243 σ_{ny} [14%], Am-241 σ_{ny}^g [10%], Pu-242 σ_{ny} [6%], Cm-242 spont. fis. [5%]

NEACRP-A - 448

HIGH PRIORITY NUCLEAR DATA MEASUREMENT REQUIREMENTS

In March 1977 a joint French, German and UK List of Category 1 Requests for Nuclear Data was produced (NEACRP-A291). The purpose was to focus international attention on a short list of the highest priority requirements and to encourage international collaboration on measurements and evaluations to meet the requirements. It was hoped that the NEANDC would be able to scrutinise the list and help to co-ordinate the international measurement and evaluation effort. The intention was also to

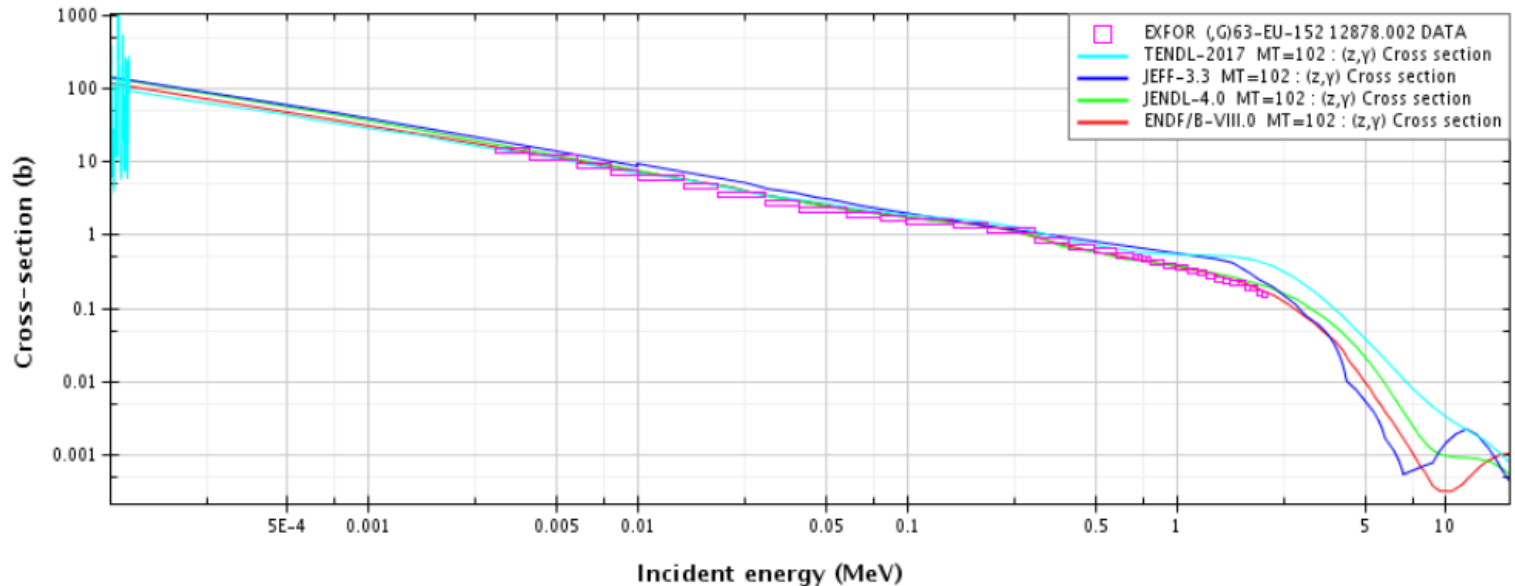
EXFOR search

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Target Z: 63 A: 151 State:	Subentry
Quantity General: CS Detailed: SIG	Title:
Reaction Incident projectile: N Process: G	Date: from 1980 to 2019
Product Z: 63 A: 152	Institute / Laboratory
Energy Range E =	

Isotope	Energy Range	Accuracy	Requester
151Eu	0.5eV-1M	5	US
152Eu	1m -1K	10	US
	100eV-500K	10	J
	Res. Param.	10	J
153Eu	1m -1K	2-5	US
154Eu	100eV-500K	10	J
	Res. Param.	10	J
167Er	1m -1eV	2	US
Hf	1m -1eV	2	US
176Hf	1m -5K	10-40	US
177Hf	1m -5K	4-20	US
178Hf	1m -5k	3-20	US
			JS
			JS

Incident neutron data // Eu151 //

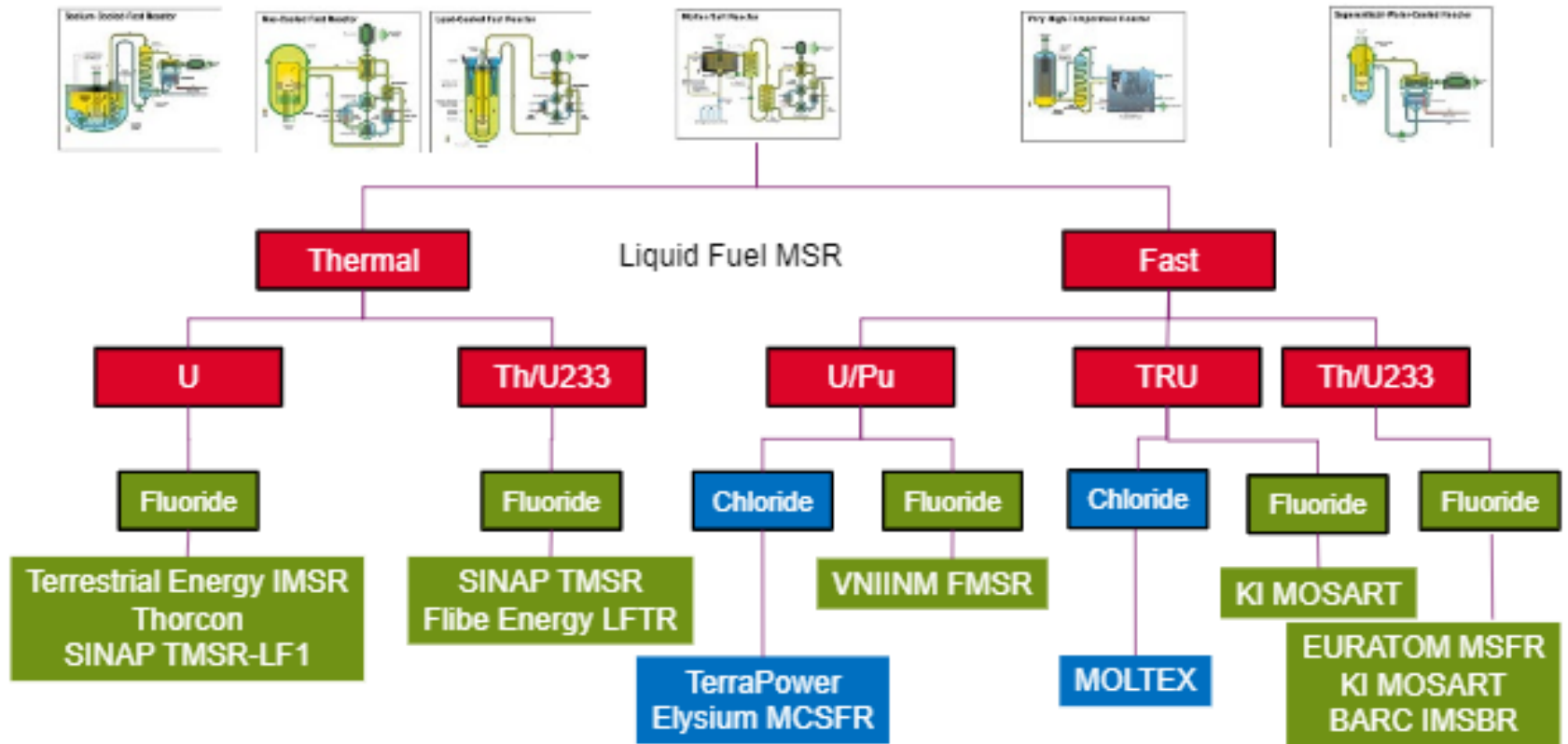


New Stuff

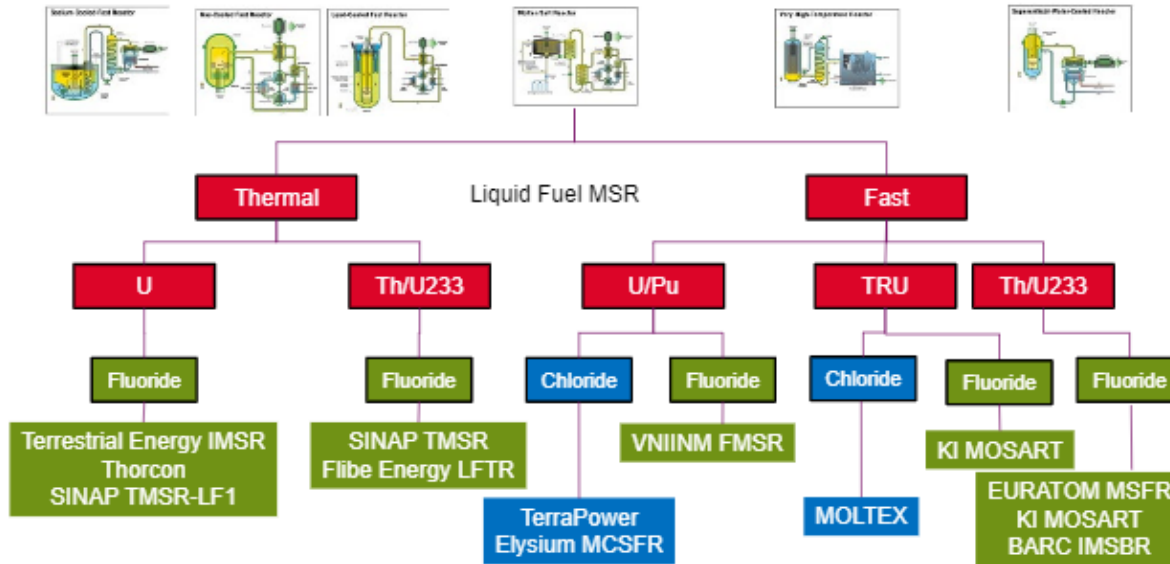
9. Actions related to MSR:

- a. **I. Hill** circulate TAR material to parties interested in MSR

The challenge faced by the GEN IV MSR systems



The challenge faced by the GEN IV MSR systems



N. Tourran: TerraPower Elysium agreement in principle to provide TAR

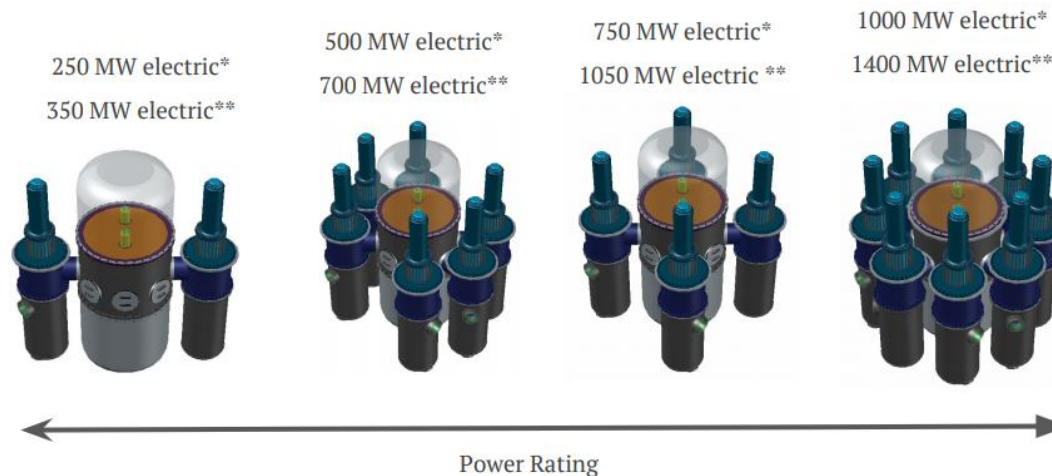
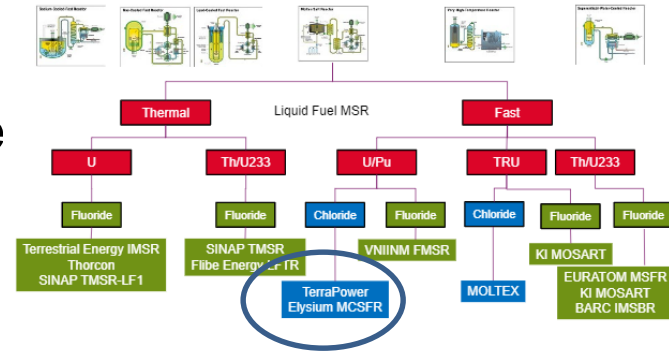
B. Petrovic: FHR agreement in principle to provide TAR

J.Krepel: Leading V&V for MSRs, waiting for response.

MCSFR

- No simplified model provided yet
- Fuel temperature coefficient, large and negative so ~10 % accuracy is OK
- Balance between Pu239 capture vs. U238 important. Burnup reactivity swing target. 200 pcm (Ian: I'm not sure over what burnup)
- Initial keff ~300 pcm.
- Chlorine is and its effects on criticality and spectrum are of continued interest.

The challenge faced by the GEN IV MSR systems

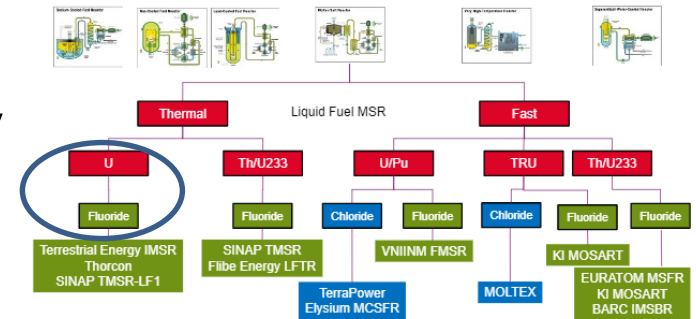


FHR

- Asks if numbers are for design/licensing/safety
- Hasn't moved towards commercialization so real TARs aren't specified yet.
- Tritium management/production is a specific issues that should be added to traditional parameters
- k_{eff} ~200 pcm BOL and 300 pcm later
- Reactivity coefficients may need high accuracy as near zero
- Many publications links sent, proposed follow-up call.

- C. Gentry, G.I. Maldonado, O. Chvala, B. Petrovic, "Neutronic Evaluation of a Liquid Salt Cooled Reactor Assembly," *Nuclear Science Engineering*, **187**, 166-184 (2017). [Study of design options]
- K. Ramey, B. Petrovic, "Monte Carlo Modeling and Simulations of AHTR Fuel Assembly to Support V&V of FHR Core Physics Methods," *Annals of Nuclear Energy*, **118**, 272-282 (2018). [Relevant sensitivities]
- L. M. Huang, B. Petrovic, "Development of Methodology for Efficient Fuel Design Evaluation of the Advanced High Temperature Reactor (AHTR)," *Annals of Nuclear Energy*, **121**, 646-660 (2018). [Mainly for fuel cycle sensitivities]

The challenge faced by the GEN IV MSR systems



Ongoing FHR benchmark in WPRS

Summary

Looked back

- Review NEA documents from the late 1970s-1980s for target accuracies
- Might be useful, depending on the structure of the final report

Looking forward

- Good leads on MSRs for TAR activity, May 2020 hopefully.
- TARs sometimes difficult to convince value. Explain current validation process, and how exercise can 'safeguard' the current performance of nuclear data