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Status of Hf Resolved Resonance Data

JEF/DOC-1324

Presented by
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Hafnium Resonance Evaluation as of November 2009

- T. Ware PhD with M. Moxon and C. Dean.
- Presentations at the last meeting:-
  - The Resolved Resonance Region of Hafnium ; T. Ware JEF/DOC 1287
  - Analysis of the 8eV Doublet in Hf, M Moxon et al JEF/DOC 1313
- At that time:-
  - Resonance parameters below 20eV were not fixed
  - Tests were not completed
  - File was not available to the CEA
  - Data were not submitted to EXFOR

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Thermal data （Mick Moxon）

- 8eV doublet data were fixed.
- Tim Ware performed a fit to Geel capture measurements that gave approximate resonance parameters.
- These were sent to Mick Moxon.
- All available thermal (2200m/s) capture and transmission data were collected from EXFOR and CINDA and references reviewed.
- Results were corrected to modern values of the standards.
- Some outlying measurements were rejected.
- Inverse variance weighting was performed to fix a 2200m/s cross section for each isotope.
- Bound levels were generated to fit these accounting for the positive resonance contributions.

Thermal cross sections of Hf Isotopes

Isotope	Natural Abundance	σγ (2200m/s) (b)	Uncertainty (b)
174Hf	0.16	648.36	33.5
176Hf	5.26	16.83	2.3
177Hf	18.6	371.05	2.6
178Hf	27.28	82.8	1.2
179Hf	13.62	39.83	1.8
180Hf	35.08	13.06	0.09
Nat-Hf	100	103.5	3.7

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Thermal cross sections and Resonance Integrals

	Cross section			Resonance integral		
Nuclide	JEFF3.1	This Work	Increase %	JEFF3.1	This Work	Increase %
174Hf	549.56	648.36	18.0	440.89	451.15	2.3
176Hf	21.32	16.83	-21.1	693.85	633.10	-8.8
177Hf	371.89	371.05	-0.2	7210.06	7164.19	-0.6
178Hf	83.95	82.80	-1.4	1871.25	1797.94	-3.9
179Hf	40.78	39.83	-2.3	508.44	529.52	4.1
180Hf	13.10	13.06	-0.3	29.59	37.20	25.7
Natural	104.22	103.53	-0.7	1968.38	1942.21	-1.3

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Tests （1）

- Two room temperature critical experiments.
- Large blocks of Hf surrounded by high enriched fuel to give the hard spectrum.
- Block size differed in the two cases.
- MONK Monte Carlo to 20pcm

Block	JEFF3.1	This Work	Difference (pcm)
Small	1.0011	1.0001	-100 (±28)
Large	1.0026	1.0010	-160 (±28)

- Results Encouraging but:-
  - Not the final file
  - Effect of JEFF3.1 data for other isotopes are not known

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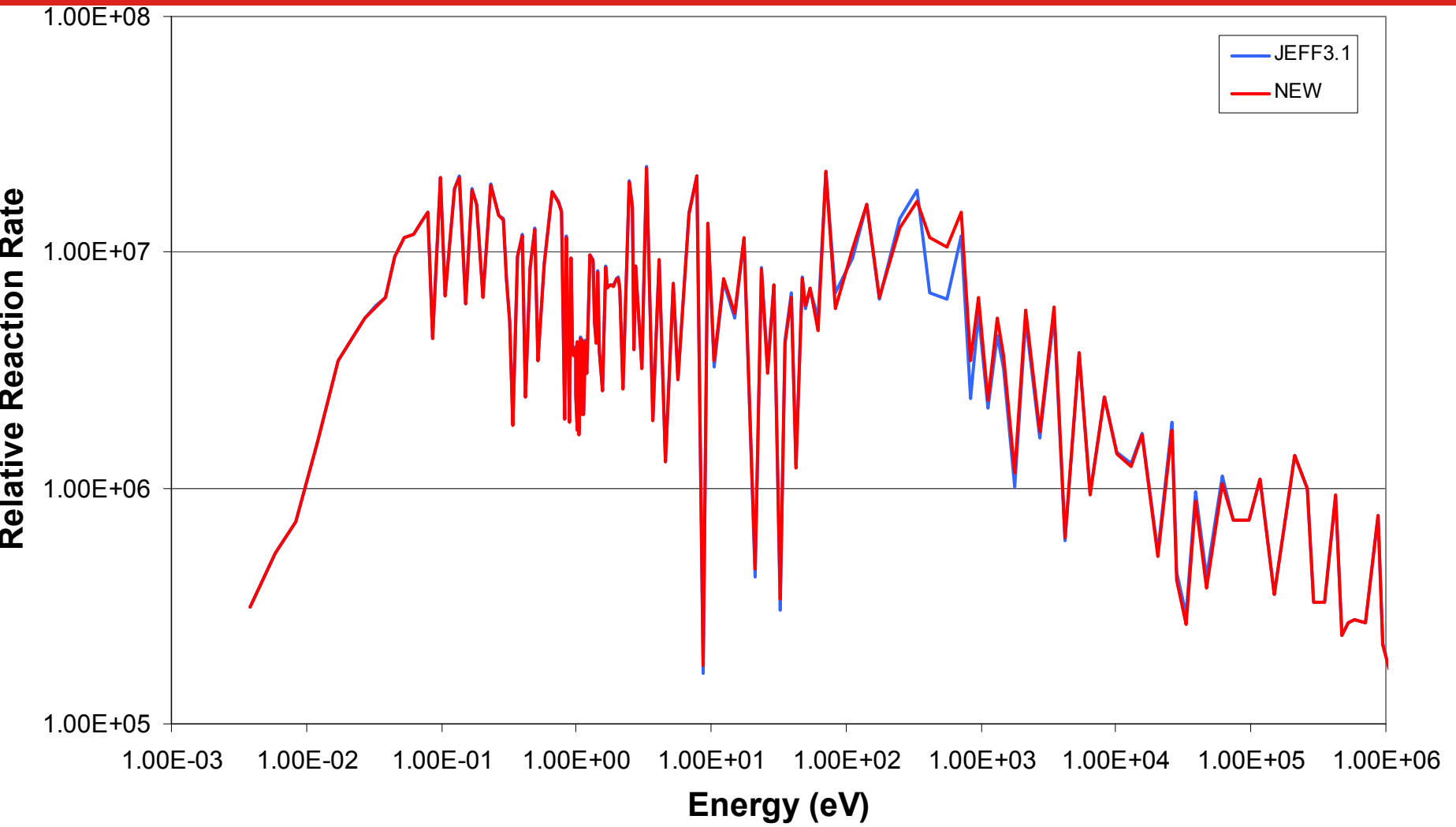
Tests （2）

- Theoretical test :- infinite slabs of enriched fuel in a Zr/water matrix.
- Hf slab at the centre, fully reflected.
- Thickness of Hf slab similar to a control rod.
- Effects of changes for each isotope studied.
- As expected Hf-177 is dominant by far.
- Where does the change come from?
- Group the reaction rates in XMAS bins.

Change in Hf-177 Reaction rates



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Current Thoughts

- Effect is from ~240 to 350eV where extra resonances are identified by Ware.
- Low energy (below 20eV) effects seem small.
- As Rods are reasonably thick for mechanical reasons the thermal resonances “black out”.
- This means even quite large changes to these resonances are unlikely to affect reaction rates in Rod.
- The situation would be different for small quantities of Hf (Poisons).
- Confirmed by Sensitivity profiles from Nogeure.

Files

- Isotopic evaluations were sent to the CEA on 11 March 2010 and copied to the NEA and other interested parties.
- EXFOR data (yields and transmissions) were sent to Geel for checking prior to formal release to EXFOR.
- Data from Mick Moxon's 1970's measurements were scanned by the NEA, checked by Mick and Tim and should be available (Important for Hf-180).
- Jack Harvey's data were also scanned and returned to him in electronic form.

Resonance Parameters

Nuclide	Upper Limit (eV)		Number	
	JEFF3.1	New File	JEFF3.1	New File
^{174}Hf	220	250	12	14
^{176}Hf	700	3000	19	74
^{177}Hf	250	1000	94	331
^{178}Hf	1500	3000	23	55
^{179}Hf	250	1000	50	219
^{180}Hf	2500	3000	16	21

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Conclusion

- New Hf resolved resonance files are available for extension by the CEA (Unresolved data).
- Measured Geel data (Yields and Transmissions) will be available in EXFOR.
- A PhD Thesis has been submitted to University of Birmingham and will be published in the coming months.
- A short paper is in the ND2010 proceedings.

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