Extended Activation and Depletion Analysis Code GRS-ORIGEN-X

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The known code ORIGEN has been applied and improved for burn-up and activation problems by GRS since 1978 up to now, applied in reactivity, shielding tasks, reactor decay heat investigations and in the waste management of the fuel cycle. The code is now extended in its method, nuclear cross sections and nuclear decay data. The development of the extended GRS-ORIGEN-X code started 2003 from the GRS standard tool (similar ORIGEN-S in SCALE-4.3). ORIGEN-X runs stand-alone, but additionally it is implemented in the burn-up code systems OREST and KENOREST.

> Extended Method

Handling of the code improved; 999 irradiation steps possible (standard is 10); 25 fission yield isotope sets (standard is 5) are used; 6 energy groups of neutron flux (standard is 3) up to 20 MeV (standard is 10 MeV); beside fission 14 nuclear induced reactions (standard is 7); 14 reactions for fission products (standard only 2) (Fig.1).

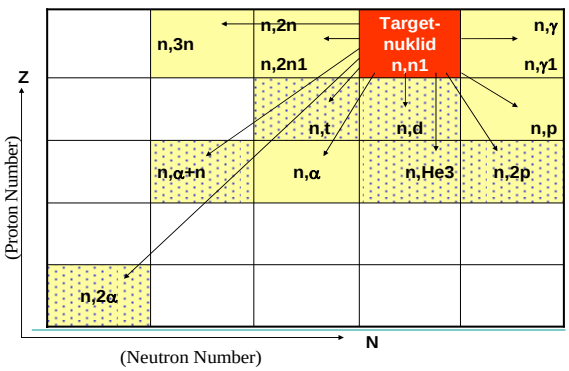

Fig.1: Neutron induced reactions in ORIGEN-X

> Updated Neutron Cross Sections

Generated completely from Point Data Files from JEF2.2, ENDF/B-VI, JENDL-3.2 and EAF97 (European Activation File) used for 500 isotopes and for 15 reaction types, inelastic scatter reactions to mesomeric isotopes included; condensed for burn-up and activation calculations for HTR, LWR, FBR and Fusion reactor types; same data used in 84 energy groups in GRS LWR burn-up systems OREST and KENOREST.

> Updated Nuclear Decay Data

ENDF/B-VI data for decay constants, energies, decay fractions and thermal, fast and 14 MeV fission yields; decay energies improved especially for the short time range. See Fig.2 for reactor decay heat tasks as deviation % from U235 burst-experiments (black points). <LIBMAST06> (red curve) is now the new ORIGEN-X database; reactor decay power problems now solved; no systematic underestimation as in ENDF/B-V or slightly underestimation in ENDF/B–VI:

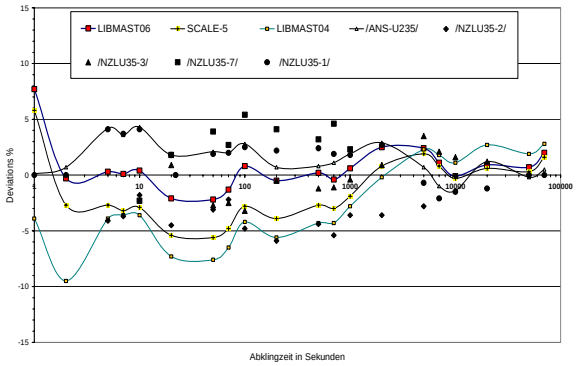

Fig.2: Decay Heat Deviations from U235 Burst Experiments

> Results and Validation for Activation

ORIGEN Tritium problem solved; Fe-60, Na-22 and Al-26 are generated (standard no); C-14 production is increased; in radioactive waste tasks after 4 year irradiation by LWR neutron fluxes considerable activity differences for 50% of all structure material elements detected compared to standard ORIGEN method and libraries.

> Results and Validation for Burn-up Tasks

Good isotopic results in OECD-benchmarks and ARIANE experiments (in work) for UO_2 and MOX reactor fuel; see in Fig.3 the GRS actinide deviations (red columns) for the OECD Takahama-Benchmark UO_2 fuel at 46 GWd:

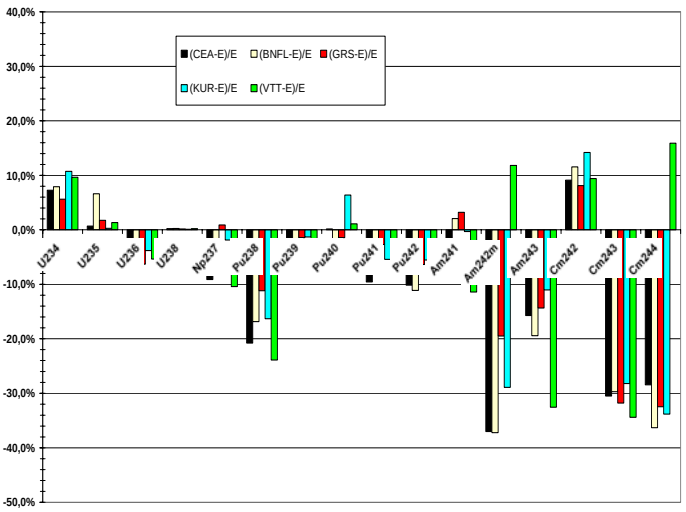

Fig. 3: Calculated masses: Deviation of benchmark-participants from the mean

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