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NOTITIE AAN : Alle medewerkers van WEH Nucleaire Fysica.
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BETREFT : VAREX3

The code VAREX2 is a tool for variational analysis of reactivity effects with XSDRNPM. VAREX2 is able to calculate temperature and density reactivity effects, factors of the four factor formula and the kinetic parameters like the delayed neutron fraction and the delayed neutron decay constants.

Since the factors of the four factor formula are not calculated correctly in case of a fuel that contains Th-232, the code has been modified. Besides that, some other modifications and extensions have been made, which has resulted in a new version of the code: VAREX3.

The modifications are listed below:

Modification because of an error in case of fuel that contains Th-232.

Due to an error in VAREX2 Th-232 is not been counted as a nuclide that belongs to the fuel. This leads to false values for the η and f from the four factor formula. In VAREX3 the procedure to check whether a nuclide belongs to the fuel, or not, has been changed.

Modification because of misinterpretation of the factors of the four-factor formula.

In VAREX2 the word 'fuel' in the definitions of the factors η (neutron production per thermal neutron absorbed in the fuel) and f (the thermal utilisation factor, which is defined as the thermal absorption rate in the fuel divided by the total thermal absorption rate) has been misinterpreted. VAREX2 interprets 'fuel' as the collection of all nuclides that have non-zero fission cross sections, i.e. the actinides. VAREX3 defines 'fuel' as the zone(s) that contain nuclides with non-zero fission cross sections. The latter interpretation results in practice in a lower η and a higher f , while the product ηf remains constant. This is caused by the fact that in VAREX3 the thermal neutron absorption of all non-actinides present in the fuel zone, like fission products and burnable poisons, is now taken into account by 'the thermal absorption in the fuel'.

Possibility to choose the first thermal energy group (IFTG)

The factors of the four factor formula are functions of both thermal and non-thermal absorption and production rates. The separation between the thermal and the non-thermal energy range is determined by the first thermal energy group (represented by the integer IFTG in the code). VAREX reads the IFTG from the AMPX-working library. Usually the IFTG is equal to 95, which corresponds with a cut-off energy of 3.3 eV in the 172 groups XMAS-structure. This value originates from the fact that ECN's AMPX master libraries are processed in such a way that the upper boundary for up-scattering is set to 3.3 eV. VAREX3 offers the possibility to use an IFTG that differs from the default value, read from the AMPX-working library. This IFTG can be given as an input parameter. An example of the command to run VAREX3 with this external parameter reads

```
varex3 namefor nameper 136 >! varex3.out
```

where the value of IFTG becomes 136.

For most calculations, it is recommended to set the IFTG to 136 for the following two reasons:

1. An IFTG of 136 corresponds with a cut-off energy of 0.625 eV. ECN's version of XSDRNPM uses this value for calculating the spectral parameters too. In this way, links between the four factors at the one hand and spectral parameters at the other can be made, which makes interpretation of the physics more easy.
2. The resonance escape probability (p) is the probability that a neutron, that is born in the non-thermal energy range

as a fission neutron, slows down to the thermal region without being absorbed by resonance absorbers in the fuel. Pu-240 is in many systems an important resonance absorber and has its lowest lying resonance at 1 eV. An IFTG of 136 means that this lowest lying resonance is just in the non-thermal energy range, which implies that the definition of p , i.e. the resonance escape probability, makes sense.

Improved readability and grepability

The lay-out of the VAREX3 output has been changed. Now, it has an improved readability and it is 'easily grepable'.

VAREX3 does not differ from VAREX2 in calculating the kinetic parameters. The memo NUC-RFA-96-01 describes how the kinetic parameters are calculated. However, the memo does not mention that there are only delayed neutron data available for the following nuclides:

Th-232, U-233, U-235, U-238, Pu-239, Pu-240, Pu-241.

The basic delayed neutron data are extracted from JEF2.2 and stored in the files `del_neu_ener_dis` and `del_neu_prod`. It should be noted that both VAREX2 and VAREX3 take for the actinides, that are not mentioned above, the delayed neutron data of Pu-239. This is because most minor actinides have effective delayed neutrons fractions that can be compared to that of Pu-239.

VAREX3 can be found under `/home/phoenix2/reactor/cbin/q0/varex3_971017`

The files that contain the delayed neutron data are stored under

`/home/phoenix2/reactor/nucdat/varex/3/`

The delayed neutron files can be linked or copied to the directory in which VAREX3 will be run. An example of a script in which the delayed neutron files are linked and VAREX3 is run, reads

```
#!/bin/csh
ln -s /home/phoenix2/reactor/nucdat/varex/3/del_neu_ener_dis_971017 del_neu_ener_dis
ln -s /home/phoenix2/reactor/nucdat/varex/3/del_neu_prod_971017      del_neu_prod
/home/phoenix2/reactor/cbin/q0/varex3_971017 namefor nameper 136  >! varex3.out
```

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