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Fusion Technology Institute
University of Wisconsin
1500 Engineering Drive
Madison, WI 53706

http://fti.neep.wisc.edu

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NEUTRON SOURCE GEOMETRY EFFECTS ON FUSION REACTOR BLANKETS

M. A. Abdou and C. W. Maynard
Department of Nuclear Engineering
University of Wisconsin

In neutronics calculations for the blanket of a D-T fueled reactor, a number of source distributions have been used. Table I summarizes some of the more important results obtained in this study.

In carrying out neutron flux calculations for a cylindrical or toroidal containment system, it was found that the results were sensitive to the one dimensional geometry chosen and to the source representation. This is particularly true of results for the first wall and the highest energy groups. To bring this out, a study has been made of a standard model system consisting of ten zones. Zone 1 contains the plasma, zone 2 a vacuum, 3 and 5 are the first and second walls, 9 is a graphite region and the remainder are breeding regions containing Lithium and structural material (94%Li - 6%Nb).

The system has been represented as both an infinite slab and an infinite cylinder. The source distribution has been represented in a number of ways to reflect that expected under different assumptions about the plasma and those in common use. The calculations used the discrete ordinates program ANISN and make a six group determination of the flux, reaction rates, and
heating for neutrons with energies from 8 to 14.1 MeV. The 
$\text{Nb}(n,2n)$ and $\text{Li}^7(n,\alpha)n$ reaction rates are quoted because of 
their importance to the tritium breeding; the $\text{Nb}(n,\alpha)$, $\text{Nb}(n,p)$, 
and Nb displacements per atom are particularly relevant to 
materials problems as well as for decay heating effects; and 
the heating rate and leakage affect cooling and shielding 
studies. The energy range was chosen to reduce costs but still 
includes almost all $(n,2n)$, $(n,\alpha)$, and $(n,p)$ reactions and about 
65% of the dpa and 35% of the breeding from $\text{Li}^7$.

The source choices include isotropic line and shell sources 
and uniform and parabolic volumetric sources in both slab and 
cylindrical geometries. The first two choices are convenient 
and have been used in the literature. The other choices are 
simulations of some common assumptions about the plasma 
distribution.

The results in Table I reflect these alternatives and the 
general study also shows the influence of the order of the 
discrete ordinates and of the scattering anisotropy on the 
important quantities.

The results in Table I can be understood approximately on 
the basis of analytical results and are qualitatively as 
expected. From the table it is seen that the slab representation 
is unacceptable since it gives results that are much too large 
in the walls. The differences, from both geometry and distribu-
tion, are due primarily to their influence on the angular neutron 
flux at the first wall boundary, were it is highly anistropic.
<table>
<thead>
<tr>
<th>Geometry Source</th>
<th>Zone</th>
<th>Cylinder Volumetric (Parabolic)</th>
<th>Cylinder Volumetric Uniform</th>
<th>Cylinder Line Uniform Isotropic</th>
<th>Slab Volumetric Uniform</th>
<th>Slab Shell Isotropic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niobium</td>
<td>3</td>
<td>4.42</td>
<td>4.56</td>
<td>.3.57</td>
<td>7.77</td>
<td>5.27</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>3.01</td>
<td>3.09</td>
<td>2.77</td>
<td>3.68</td>
<td>3.32</td>
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<tr>
<td>$(n,\alpha) \times 10^4$</td>
<td>$T_a$</td>
<td>15.01</td>
<td>15.21</td>
<td>14.1</td>
<td>18.4</td>
<td>16.02</td>
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<td>1.46</td>
<td>1.50</td>
<td>1.18</td>
<td>2.56</td>
<td>1.74</td>
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<tr>
<td>$(n,p) \times 10^3$</td>
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<td>1.01</td>
<td>1.03</td>
<td>.926</td>
<td>1.23</td>
<td>1.11</td>
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<td></td>
<td>$T_a$</td>
<td>5.07</td>
<td>5.13</td>
<td>4.77</td>
<td>6.17</td>
<td>5.41</td>
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<td>7.72</td>
<td>6.06</td>
<td>13.06</td>
<td>8.90</td>
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<td>dpa$\times 10^2$</td>
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<td>5.24</td>
<td>5.38</td>
<td>4.80</td>
<td>6.40</td>
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<tr>
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<td>2.11</td>
<td>2.18</td>
<td>1.70</td>
<td>3.72</td>
<td>2.51</td>
</tr>
<tr>
<td>$(n,2n) \times 10^2$</td>
<td>5</td>
<td>1.42</td>
<td>1.46</td>
<td>1.31</td>
<td>1.74</td>
<td>1.57</td>
</tr>
<tr>
<td></td>
<td>$T_a$</td>
<td>7.04</td>
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<td>8.66</td>
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<td>Lithium-7</td>
<td>4</td>
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<td>.064</td>
<td>.054</td>
<td>.089</td>
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<td>$(n,\alpha')T$</td>
<td>$T_b$</td>
<td>.395</td>
<td>.394</td>
<td>.404</td>
<td>.361</td>
<td>.387</td>
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<tr>
<td>Neutron</td>
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<td>.81</td>
<td>.83</td>
<td>.65</td>
<td>1.41</td>
<td>0.96</td>
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<td>Heating</td>
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<td>15.78</td>
<td>16.27</td>
<td>13.77</td>
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<td>Rate in Watts$\times 10^4$</td>
<td>$T_b$</td>
<td>0.55</td>
<td>0.57</td>
<td>0.51</td>
<td>0.675</td>
<td>0.61</td>
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<td>Leakage Watts$\times 10^4$</td>
<td>$T_c$</td>
<td>95.95</td>
<td>95.58</td>
<td>97.94</td>
<td>87.62</td>
<td>94.07</td>
</tr>
</tbody>
</table>

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`a.` sum over all zones (for neutrons above 8 Mev)
`b.` sum over breeding zones (for neutrons above 8 Mev)
`c.` sum for neutrons above 8 Mev (assuming no reflection)
References


