FUSION-DRIVEN TRANSMUTATION OF SELECTED LONG-LIVED FISSION PRODUCTS

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**SPENT FUEL COMPOSITION**

**MASS OUTPUT NORMALIZED PER 1GWTYR OF FISSION ENERGY**

Total Spent Fuel Composition

- **U (8.5T)**
- **Pu (80kg)**
- **FP (300kg)**
- **MA+Other (6.6kg)**

FP Composition

- **Stable+>5×10^9Yr (270kg)**
- **<5×10^9Yr (36kg)**

Radioactive FP Composition

- **1-30Yr (16kg)**
- **<1Yr (240g)**
- **10000-5×10^9Yr (20kg)**
- **30-10000Yr (120g)**

**Footnote:** PWR 33GWtd·THM⁻¹ burnup and 3Yr cooling spent fuel
MASS BUILDUP OF RADIOACTIVE SPECIES

Accumulated Mass [kg/GWt]

Time [Yr]

EQUILIBRIUM MASS

HALFLIFE

Footnote: -------------------------
ACCUMULATION OF FISSION PRODUCTS

Footnote: PWR 33GW·THM⁻¹ burnup and 3Yr cooling spent fuel
# LLFP Nuclear Reaction Data

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Capture Thermal Point [barn]</th>
<th>Resonance Integral [barn]</th>
<th>(n,2n) Threshold [MeV]</th>
<th>(n,3n) Threshold [MeV]</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{79}$Se</td>
<td>50</td>
<td>61</td>
<td>7.1</td>
<td>18</td>
</tr>
<tr>
<td>$^{126}$Sn</td>
<td>0.090</td>
<td>0.15</td>
<td>8.3</td>
<td>14</td>
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<tr>
<td>$^{99}$Tc</td>
<td>20</td>
<td>310</td>
<td>9.1</td>
<td>16</td>
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<tr>
<td>$^{93}$Zr</td>
<td>2.2</td>
<td>18</td>
<td>6.8</td>
<td>16</td>
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<tr>
<td>$^{135}$Cs</td>
<td>8.7</td>
<td>63</td>
<td>8.9</td>
<td>16</td>
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<tr>
<td>$^{98}$Tc</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>$^{107}$Pd</td>
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<td>110</td>
<td>6.6</td>
<td>16</td>
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<td>$^{129}$I</td>
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<td>29</td>
<td>8.9</td>
<td>16</td>
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<td>$^{146}$Sm</td>
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<td>N/A</td>
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<td>N/A</td>
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</tbody>
</table>

Footnote: Taken from JENDL3.2 nuclear data library
LLFP TRANSMUTATION IN THERMAL REACTOR

REFERENCE POINT

Typical Flux Level:
\[ \Phi = 10^{14}\text{cm}^{-2}\text{s}^{-1} \]

Footnote: --------------------------
LLFP TRANSMUTATION IN FAST REACTOR

REFERENCE POINT

Typical Flux Level: \( \Phi = 10^{15}\text{cm}^{-2}\text{s}^{-1} \)

Footnote: -------------------------
FUSION NEUTRON SOURCE

Neutron Availability → Flux is mostly governed by FWL value

Neutron Quality → Great FLEXIBILITY to create neutron spectrum desired

THERMAL FLUX BLANKET BASIC CONCEPT

| Plasma | FW [SiC] 2cm | Multiplier [Lead+\(^6\)Li] 25cm | Transmutation Zone [Graphite+LLFP] 50cm | Shielding |

Footnote: -------------------------

Great FLEXIBILITY to create neutron spectrum desired

Flux is mostly governed by FWL value
SPECTRA OVER TRANSMUTATION ZONE

Footnote: -------------------------
LLFP TRANSMUTATION IN FUSION FACILITY

REFERENCE POINT

First Wall Loading: FWL=1MWt·m⁻²

Footnote: -------------------------
### LLFP Transmutation Efficiency

<table>
<thead>
<tr>
<th>Facility</th>
<th>$^{93}$Zr Effective Halflife [Yr]</th>
<th>$^{93}$Zr Equilibrium Mass [kg·GWt$^{-1}$]</th>
<th>$^{126}$Sn Effective Halflife [Yr]</th>
<th>$^{126}$Sn Equilibrium Mass [kg·GWt$^{-1}$]</th>
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</thead>
<tbody>
<tr>
<td>Thermal Reactor</td>
<td>210</td>
<td>2000</td>
<td>4700</td>
<td>1600</td>
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<tr>
<td>Fast Reactor</td>
<td>260</td>
<td>1400</td>
<td>3000</td>
<td>1700</td>
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<tr>
<td>DT Fusion</td>
<td>51</td>
<td>470</td>
<td>1900</td>
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<td>DD Fusion</td>
<td>3.3</td>
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</table>

Footnote: -------------------------
CONCLUSION

LLFP transmutation by means of fission facilities is not efficient enough to drastically reduce the burden associated with LLFP.

Given its neutron environment FNS is appearing to be the candidate No.1 for LLFP transmutation.

In the study presented the potential of thermal flux blanket of FNS has been analyzed on $^{93}$Zr and $^{126}$Sn the most difficult LLFP to transmute.