


| Fuel properties  | Correlations   |
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| Melting temperature (K)<br>(bu in [GWd/t <sub>HM</sub> ])  | $T_m = 2964.92 + [(3147 - 364.85 \cdot [\text{Pu}] - 1014.15 \cdot x) - 2964.92] \cdot e^{\frac{-bu}{40.43}}$  |
| Thermal conductivity (W m <sup>-1</sup> K <sup>-1</sup> ) – U-Pu MOX<br>(T in [K], bu in [/ FIMA] = fractional burnup)           | $\lambda = \left( \frac{1}{1.528\sqrt{x} + 0.0093 - 0.1055 + 0.44 \cdot bu + 2.885 \cdot 10^{-4} \cdot T} + 76.4 \cdot 10^{-12} \cdot T^3 \right) \cdot 1.16 \cdot \frac{1-p}{1+2p}$   |
| Thermal conductivity (W m <sup>-1</sup> K <sup>-1</sup> ) – UO <sub>2-x</sub><br>(T in [°C], bu in [/ FIMA] = fractional burnup) | $\lambda = \left( \frac{1}{0.115 + 2.6 \cdot 10^{-3} \cdot bu + 2.475 \cdot 10^{-4} \cdot T} + 1.216 \cdot 10^{-2} \cdot e^{1.867 \cdot 10^{-3} \cdot T} \right) \cdot \frac{1 - (2.58 - 5.8 \cdot 10^{-4} \cdot T) \cdot p}{1 - (2.58 - 5.8 \cdot 10^{-4} \cdot T) \cdot 0.05}$ |
| Linear thermal expansion coefficient (°C <sup>-1</sup> )<br>(reference: 25°C)  | $\alpha_L = 1.2 \cdot 10^{-5}$   |
| Young's modulus (MPa)  | $E = (22.43 \cdot 10^4 - 31.19 \cdot T[^\circ\text{C}]) \cdot (1 - 2.6 \cdot p)$   |
| Poisson coefficient (-)  | $\nu = 0.32$   |
| Swelling strain (%) (bu in [GWd/t <sub>HM</sub> ])   | $\epsilon_{\text{swe,tot}} = 0.07 \cdot bu$  |

| Cladding properties  |  |
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| Melting temperature (°C)   | $T_m = 1400$   |
| Linear thermal expansion  | $\epsilon_{\text{th}} = -3.101 \cdot 10^{-4} + 1.545 \cdot 10^{-5} \cdot T[^\circ\text{C}] + 2.75 \cdot 10^{-9} \cdot T[^\circ\text{C}]^2$   |
| Density (kg m <sup>-3</sup> )  | $\rho = 7900 \cdot (1 + \epsilon_{\text{th}})^{-3}$  |
| Specific heat (J kg <sup>-1</sup> K <sup>-1</sup> )  | $c_p = 431 + 0.77 \cdot T[\text{K}] + 8.72 \cdot 10^{-5} \cdot T[\text{K}]^2$  |
| Thermal conductivity (W m <sup>-1</sup> K <sup>-1</sup> )  | $\lambda = 13.95 + 0.01163 \cdot T[^\circ\text{C}]$  |
| Young's modulus (GPa)  | $E = 202.7 - 81.67 \cdot 10^{-3} \cdot T[^\circ\text{C}]$  |
| Poisson coefficient (-)  | $\nu = 0.277 + 6 \cdot 10^{-5} \cdot T[^\circ\text{C}]$  |
| Yield stress (MPa) at 0.2% strain  | $\sigma_{Y,0.2\%} \begin{cases} 555.5 - 0.25 \cdot T[^\circ\text{C}] & \text{if } T < 600^\circ\text{C} \\ 405.5 - 0.775 \cdot (T[^\circ\text{C}] - 600) & \text{if } 600^\circ\text{C} < T < 1000^\circ\text{C} \\ 345.5 - 0.25 \cdot T[^\circ\text{C}] & \text{if } T > 1000^\circ\text{C} \end{cases}$      |
| Ultimate tensile strength (UTS) (MPa)  | $\sigma_{\text{UTS}} \begin{cases} 700 - 0.3125 \cdot T[^\circ\text{C}] & \text{if } T < 600^\circ\text{C} \\ 512.5 - 0.969 \cdot (T[^\circ\text{C}] - 600) & \text{if } 600^\circ\text{C} < T < 1000^\circ\text{C} \\ 437.5 - 0.3125 \cdot T[^\circ\text{C}] & \text{if } T > 1000^\circ\text{C} \end{cases}$ |
| Rupture strain (%)   | $\epsilon_{\text{rupt}} = 8 + 4.74 \cdot 10^{-3} \cdot (T[^\circ\text{C}] - 500) + 6.2 \cdot 10^{-5} \cdot (T[^\circ\text{C}] - 500)^2$  |
| Void swelling (%)  | $\frac{\Delta V}{V} = 1.5 \cdot 10^{-3} \exp \left[ -2.5 \left( \frac{T[^\circ\text{C}] - 450}{100} \right)^2 \right] \left( \frac{\varphi}{10^{22}} \right)^{2.75}$   |
| Thermal creep strain rate (% h <sup>-1</sup> )   | $\dot{\epsilon}_\theta = 2.3 \cdot 10^{14} \exp \left( \frac{-84600}{R \cdot T[\text{K}]} \right) \sinh \left( \frac{34.54 \cdot \sigma_{\text{eq}}}{0.8075 \cdot R \cdot T[\text{K}]} \right)$  |
| Irradiation creep strain rate (% h <sup>-1</sup> )   | $\dot{\epsilon}_{\text{irr}} = 3.2 \cdot 10^{-24} \cdot \bar{E} \cdot \phi \cdot \sigma_{\text{eq}}$   |
| Larson-Miller parameter (LMP)  | $\text{LMP} = \begin{cases} T[\text{K}] \cdot (17.125 + \log_{10}(t_{\text{rupt}})) \\ \frac{2060 - \sigma_{\text{eq}}}{0.095} \end{cases}$  |

| Coolant properties  |  |
|---|--|
| Melting temperature (°C) at atmospheric pressure                      | $T_m = 98$   |
| Boiling temperature (°C) at atmospheric pressure                      | $T_b = 882$  |
| Specific heat (J kg <sup>-1</sup> K <sup>-1</sup> )                   | $c_p = 971.34 - 3.69 \cdot 10^{-1} \cdot T[^\circ\text{C}] + 3.43 \cdot 10^{-4} \cdot T[^\circ\text{C}]^2$                   |
| Density (kg m <sup>-3</sup> )   | $\rho = 954.1579 + T[^\circ\text{F}] \cdot (T[^\circ\text{F}] \cdot 0.9667 \cdot 10^{-9} - 0.46 \cdot 10^{-5}) - 0.1273534)$ |
| Dynamic viscosity (Pas)   | $\eta = 10^{-3} \exp \left( 2.3 \cdot (0.5108 + \frac{220.65}{T[\text{K}]} - 0.2139 \cdot \log(T)) \right)$                  |
| Thermal conductivity (W m <sup>-1</sup> K <sup>-1</sup> )             | $\lambda = 94 - 3.25 \cdot 10^{-2} \cdot T[^\circ\text{F}] + 3.62 \cdot 10^{-6} \cdot T[^\circ\text{F}]^2$                   |
| Nusselt number (-)  | $\text{Nu} = 7 + 0.025 \cdot \text{Pe}^{0.8}$  |
| Filling gas Thermal conductivity (W m <sup>-1</sup> K <sup>-1</sup> ) | $\lambda_{\text{He}} = 15.8 \cdot 10^{-4} \cdot T[\text{K}]^{0.79}$  |

**Variables:** bu = burnup (/ FIMA or GWd/t<sub>HM</sub>);  $\bar{E}$  = mean neutron energy (MeV); p: porosity (/TD); [Pu]: Pu content (at%); R = gas constant = 1.986 cal mol<sup>-1</sup> K<sup>-1</sup>;

T: temperature (°C or K or °F); t<sub>rupt</sub> = time-to-rupture (h); x = 2.00-0/M: deviation from stoichiometry (-);  $\varphi$  = neutron fluence (n cm<sup>-2</sup>);  $\phi$ : neutron flux (n cm<sup>-2</sup> s<sup>-1</sup>);

$\sigma_{\text{eq}}$  = Von Mises equivalent stress (MPa).