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(* Decay heat calculation according to the simplified DIN25463-1990 formula *)
(* The decay heat calculation according
 to the 1990 formula is very simple as compared to
 the updated standard from 2014. Old 1990
 standard: "https://www.beuth.de/de/norm/din-25463-1/1549611"
   New 2014 standard: "https://www.beuth.de/de/norm/din-25463-1/194886177" *)
(* The 1990 standard also contained a simplified
 formula which in essence is an evelope function
 to cover different enrichments etc. *)
(* As input you have to define a power history as a step-wise function *)

gamma = {
    {7.552*10^-2, 7.546*10^-2, 7.602*10^-2},
    {2.040*10^0, 1.532*10^0, 1.191*10^0},
    {-1.991*10^-1, -1.934*10^-1, -1.918*10^-1}
   };

a = {
    {9.023*10^-2, 1.069*10^-1, 1.207*10^-1},
    {5.056*10^0, 5.226*10^0, 5.310*10^0},
    {-1.659*10^+2, -1.705*10^+2, -1.624*10^+2},
    {-5.716*10^+2, -8.356*10^+2, -9.077*10^+2},
    {-1.022*10^+4, -1.127*10^+4, -1.126*10^+4},
    {-6.498*10^+4, -7.328*10^+4, -7.644*10^+4}
   };

b = {
    {2.611*10^+3, 1.734*10^+3, 1.389*10^+3},
    {2.286*10^+6, 2.158*10^+6, 2.115*10^+6},
    {2.389*10^+10, 2.287*10^+10, 2.214*10^+10},
    {2.411*10^+13, 1.764*10^+13, 1.740*10^+13},
    {6.881*10^+14, 6.948*10^+14, 6.904*10^+14},
    {1.763*10^+16, 1.846*10^+16, 1.869*10^+16}
   };

c = {
    {9.156*10^-5, 1.717*10^-4, 1.683*10^-4},
    {-2.883*10^+1, -1.969*10^+1, -2.086*10^+1}
   };

FAHC = {
    {0, 1.027},
    {1.0, 1.028}, {1.5, 1.028}, {2.0, 1.029},
    {3.0, 1.029}, {4.0, 1.030}, {6.0, 1.031}, {8.0, 1.031},
    {10.0, 1.033}, {15.0, 1.034}, {20.0, 1.034}, {30.0, 1.034}, {40.0, 1.035},
    {60.0, 1.037}, {80.0, 1.037}, {100.0, 1.037}, {150.0, 1.039}, {200.0, 1.041},
    {300.0, 1.042}, {400.0, 1.044}, {600.0, 1.049}, {800.0, 1.052},
    {1000.0, 1.055}, {1500.0, 1.059}, {2000.0, 1.063}, {3000.0, 1.070},
    {4000.0, 1.075}, {6000.0, 1.084}, {8000.0, 1.091}, {10 000, 1.097},
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    {15 000, 1.109}, {20 000, 1.118}, {30 000, 1.131}, {40 000, 1.142},
    {60 000, 1.158}, {80 000, 1.168}, {1.0 * 10^5, 1.177}, {1.5 * 10^5, 1.188},
    {2.0 * 10^5, 1.195}, {3.0 * 10^5, 1.201}, {4.0 * 10^5, 1.203},
    {6.0 * 10^5, 1.206}, {8.0 * 10^5, 1.210}, {1.0 * 10^6, 1.213}, {1.5 * 10^6, 1.223},
    {2.0 * 10^6, 1.231}, {3.0 * 10^6, 1.247}, {4.0 * 10^6, 1.258}, {6.0 * 10^6, 1.285},
    {8.0 * 10^6, 1.310}, {1.0 * 10^7, 1.331}, {1.5 * 10^7, 1.378}, {2.0 * 10^7, 1.415},
    {3.0 * 10^7, 1.466}, {4.0 * 10^7, 1.503}, {6.0 * 10^7, 1.565}, {8.0 * 10^7, 1.628},
    {1.0 * 10^8, 1.691}, {1.5 * 10^8, 1.785}, {2.0 * 10^8, 1.799}, {3.0 * 10^8, 1.721}
   };

BMAX = {
    {0, 3.741 * 10^-3}, {1.0, 3.740 * 10^-3},
    {1.5, 3.740 * 10^-3}, {2.0, 3.739 * 10^-3},
    {3.0, 3.738 * 10^-3}, {4.0, 3.737 * 10^-3},
    {6.0, 3.736 * 10^-3}, {8.0, 3.734 * 10^-3},
    {10.0, 3.732 * 10^-3}, {15.0, 3.727 * 10^-3},
    {20.0, 3.722 * 10^-3}, {30.0, 3.712 * 10^-3},
    {40.0, 3.703 * 10^-3}, {60.0, 3.684 * 10^-3},
    {80.0, 3.665 * 10^-3}, {100.0, 3.646 * 10^-3},
    {150.0, 3.600 * 10^-3}, {200.0, 3.555 * 10^-3},
    {300.0, 3.469 * 10^-3}, {400.0, 3.387 * 10^-3},
    {600.0, 3.233 * 10^-3}, {800.0, 3.095 * 10^-3},
    {1000.0, 2.969 * 10^-3}, {1500.0, 2.702 * 10^-3},
    {2000.0, 2.493 * 10^-3}, {3000.0, 2.200 * 10^-3},
    {4000.0, 2.019 * 10^-3}, {6000.0, 1.833 * 10^-3},
    {8000.0, 1.757 * 10^-3}, {10 000, 1.721 * 10^-3},
    {15 000, 1.678 * 10^-3}, {20 000, 1.649 * 10^-3},
    {30 000, 1.594 * 10^-3}, {40 000, 1.540 * 10^-3},
    {60 000, 1.439 * 10^-3}, {80 000, 1.344 * 10^-3},
    {1.0 * 10^5, 1.255 * 10^-3}, {1.5 * 10^5, 1.058 * 10^-3},
    {2.0 * 10^5, 8.925 * 10^-4}, {3.0 * 10^5, 6.346 * 10^-4},
    {4.0 * 10^5, 4.512 * 10^-4}, {6.0 * 10^5, 2.281 * 10^-4},
    {8.0 * 10^5, 1.154 * 10^-4}, {1.0 * 10^6, 5.832 * 10^-5},
    {1.5 * 10^6, 1.060 * 10^-5},
    {2.0 * 10^6, 1.927 * 10^-6}, {3.0 * 10^6, 6.367 * 10^-8},
    {4.0 * 10^6, 2.104 * 10^-9},
    {6.0 * 10^6, 2.297 * 10^-12}, {8.0 * 10^6, 2.507 * 10^-15}, {1.0 * 10^7, 0.0},
    {1.5 * 10^7, 0.0}, {2.0 * 10^7, 0.0},
    {3.0 * 10^7, 0.0}, {4.0 * 10^7, 0.0}, {6.0 * 10^7, 0.0},
    {8.0 * 10^7, 0.0}, {1.0 * 10^8, 0.0}, {1.5 * 10^8, 0.0},
    {2.0 * 10^8, 0.0}, {3.0 * 10^8, 0.0}
   };

FA = Interpolation[FAHC];
BM = Interpolation[BMAX];

(* n=1 is a conservative estimate of
   the upper bound of the decay heat assuming sigma=0 *)
(* n=2 is a conservative estimate of the upper bound
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   of the decay heat assuming sigma=1 *)
(* n=3 is a conservative estimate of the upper bound
   of the decay heat assuming sigma=2 *)

Fv[t_, n_] := gamma[[1]][[n]] * (gamma[[2]][[n]] + t) ^ (gamma[[3]][[n]]) + c[[1]][[n]] *
    Exp[c[[2]][[n]] * t] + Sum[(a[[j]][[n]] / Sqrt[b[[j]][[n]] + t^2]), {j, 1, 6}];

(* the power history has to be defined in such a manner that t=
 0 equals end of life EOL *)

tk = {300 + 60 + 300 + 60, 300 + 60, 0};
Tk = {300, 300, 300};

power[t_] := UnitStep[t + tk[[1]] + Tk[[1]]] - UnitStep[t + tk[[1]]] +
   UnitStep[t + tk[[2]] + Tk[[2]]] - UnitStep[t + tk[[2]]] +
   UnitStep[t + tk[[3]] + Tk[[3]]] - UnitStep[t + tk[[3]]];

Plot[power[t], {t, -1200, 100}, PlotStyle → {Red, Thick}, Filling → Bottom]
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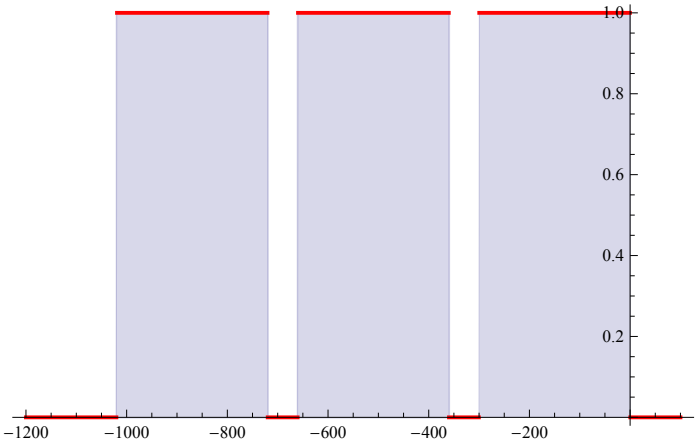

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DayToSec = 24 * 60 * 60;

DecayHeat[t_, n_] :=
  FA[t] * Sum[(Fv[tk[[j]] * DayToSec + t, n] - Fv[(tk[[j]] + Tk[[j]]) * DayToSec + t, n]),
     {j, 1, 3}] + BM[t];

results = {
   {0.1, DecayHeat[0.1, 2] },
   {1, DecayHeat[1, 2] },
   {10, DecayHeat[10, 2] },
   {100, DecayHeat[100, 2] },
   {1000, DecayHeat[1000, 2] },
   {10^4, DecayHeat[10^4, 2] },
   {10^5, DecayHeat[10^5, 2] },
   {10^6, DecayHeat[10^6, 2] },
   {10^7, DecayHeat[10^7, 2] },
   {10^8, DecayHeat[10^8, 2] }
  };

results
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{{0.1, 0.0764875}, {1, 0.0707629}, {10, 0.0544559}, {100, 0.0362458},
 {1000, 0.0229125}, {10 000, 0.0118817}, {100 000, 0.00644069},
 {1 000 000, 0.00274417}, {10 000 000, 0.000890494}, {100 000 000, 0.000110294}}
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ListLogLogPlot[results, PlotStyle → {Red, Thick}]
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