MathCad Worksheet		TAC:
S.F. LaVie, *NRR/DSSA/SPSB*	Catawba LOCA / LRA / REA Scaling Confirmation	

INITIALIZATIONS

$Ci := 3.7 \cdot 10^{10} \cdot sec^{-1}$ $rem := 100 \cdot \frac{erg}{gm}$ $Bq := 1.0 \cdot sec^{-1}$ $MWt := 1.0 \cdot 10^{6} \cdot watt$

$ORIGIN := 1$ $uCi := 1.0 \cdot 10^{-6} \cdot Ci$ $j := 1 .. 17$ $mrem := 0.001 \cdot rem$ $Sv := 100 \cdot rem$

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$\Delta ST := 1.09$ Increase due to increased source term MOX over LEU

$\Delta GF := 1.5$ Increase due to increased gap fraction MOX over LEU

LOCA -- All assemblies (193) are assumed damaged in a LOCA--189 LEU, 4 MOX

For the EAB thyroid dose , the CLB dose $D_{clb} := 89 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{193}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{189}{193} \qquad D_f = 90.171 \cdot rem \qquad \frac{D_f}{D_{clb}} = 101.316 \cdot \%$$

due to 4 MOX due to LEU final dose increase

For the LPZ thyroid dose , the CLB dose $D_{clb} := 25 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{193}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{189}{193} \qquad D_f = 25.329 \cdot rem \qquad \frac{D_f}{D_{clb}} = 101.316 \cdot \%$$

For the CR thyroid dose , the CLB dose $D_{clb} := 5.3 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{193}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{189}{193} \qquad D_f = 5.37 \cdot rem \qquad \frac{D_f}{D_{clb}} = 101.316 \cdot \%$$

LRA -- 21 assemblies are assumed damaged in a LRA--17 LEU, 4 MOX

For the EAB thyroid dose , the CLB dose $D_{clb} := 3.7 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{21}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{17}{21} \qquad D_f = 4.148 \cdot rem \qquad \frac{D_f}{D_{clb}} = 112.095 \cdot \%$$

For the LPZ thyroid dose , the CLB dose $D_{clb} := 1.2 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{21}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{17}{21} \qquad D_f = 1.345 \cdot rem \qquad \frac{D_f}{D_{clb}} = 112.095 \cdot \%$$

REA -- 97 assemblies are assumed damaged in a REA, 93 LEU, 4 MOX

For the EAB thyroid dose , the CLB dose $D_{clb} := 1.0 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{97}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{93}{97} \qquad D_f = 1.026 \cdot rem \qquad \frac{D_f}{D_{clb}} = 102.619 \cdot \%$$

For the LPZ thyroid dose , the CLB dose $D_{clb} := 0.1 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{97}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{93}{97} \qquad D_f = 0.103 \cdot rem \qquad \frac{D_f}{D_{clb}} = 102.619 \cdot \%$$

The results above were calculated with the 9% increase projected by Duke based on an equivalent assembly. The staff believes that the CLB LEU inventory should have been used instead. The increase would have been 15.8%. The doses are recalculated using the 1.158 multiplier.

$\Delta ST := 1.158$ Increase due to increased source term MOX over LEU

$\Delta GF := 1.5$ Increase due to increased gap fraction MOX over LEU

LOCA -- All assemblies (193) are assumed damaged in a LOCA--189 LEU, 4 MOX

For the EAB thyroid dose , the CLB dose $D_{clb} := 89 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{193}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{189}{193} \qquad D_f = 90.359 \cdot rem \qquad \frac{D_f}{D_{clb}} = 101.527 \cdot \%$$

due to 4 MOX due to LEU final dose increase

For the LPZ thyroid dose , the CLB dose $D_{clb} := 25 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{193}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{189}{193} \qquad D_f = 25.382 \cdot rem \qquad \frac{D_f}{D_{clb}} = 101.527 \cdot \%$$

For the CR thyroid dose , the CLB dose $D_{clb} := 5.3 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{193}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{189}{193} \qquad D_f = 5.381 \cdot rem \qquad \frac{D_f}{D_{clb}} = 101.527 \cdot \%$$

LRA -- 21 assemblies are assumed damaged in a LRA--17 LEU, 4 MOX

For the EAB thyroid dose , the CLB dose $D_{clb} := 3.7 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{21}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{17}{21} \qquad D_f = 4.219 \cdot rem \qquad \frac{D_f}{D_{clb}} = 114.038 \cdot \%$$

For the LPZ thyroid dose , the CLB dose $D_{clb} := 1.2 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{21}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{17}{21} \qquad D_f = 1.368 \cdot rem \qquad \frac{D_f}{D_{clb}} = 114.038 \cdot \%$$

REA -- 97 assemblies are assumed damaged in a REA--93 LEU, 4 MOX

For the EAB thyroid dose , the CLB dose $D_{clb} := 1.0 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{97}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{93}{97} \qquad D_f = 1.03 \cdot rem \qquad \frac{D_f}{D_{clb}} = 103.039 \cdot \%$$

For the LPZ thyroid dose , the CLB dose $D_{clb} := 0.1 \cdot rem$

$$D_f := \left[\left(\frac{D_{clb}}{97}\right) \cdot 4 \cdot \Delta ST \cdot \Delta GF\right] + D_{clb} \cdot \frac{93}{97} \qquad D_f = 0.103 \cdot rem \qquad \frac{D_f}{D_{clb}} = 103.039 \cdot \%$$

Although the staff's results using the CLB LEU source term rather than the equivalent LEU assembly used by Duke are slightly higher, they confirm Duke's conclusion that the increased doses due to 4 MOX LTA remain acceptable.

MathCad Worksheet

MathCad Worksheet	TAC:
S.F. LaVie, *NRR/DSSA/SPSB*	Evaluate impact of noble gas increases

INITIALIZATIONS

$Ci := 3.7\cdot10^{10}\cdot sec^{-1}$ $\quad rem := 100\cdot\frac{erg}{gm}$ $\quad Bq := 1.0\cdot sec^{-1}$ $\quad MWt := 1.0\cdot10^{6}\cdot watt$

$ORIGIN := 1$ $\quad uCi := 1.0\cdot10^{-6}\cdot Ci$ $\quad j := 1..17$ $\quad mrem := 0.001\cdot rem$ $\quad Sv := 100\cdot rem$

Read in nuclide database NUCLIDE.DAT.>>>>> $M := READPRN(nuclide)$

Re-assign arrays and assign units

$n := M^{<1>}$ $\quad F_g := M^{<8>}$ $\quad DCF_{dde} := M^{<5>}\cdot\frac{rem}{Ci}\cdot\frac{m^3}{sec}$

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Source term of MOX and LEU assembly

$$C_{mox} := \begin{bmatrix} 1.0\cdot10^{6} \\ 3.34\cdot10^{4} \\ 4.12\cdot10^{5} \\ 2.38\cdot10^{5} \end{bmatrix}\cdot Ci \qquad C_{leu} := \begin{bmatrix} 9.33\cdot01^{5} \\ 3.01\cdot01^{4} \\ 1.42\cdot10^{5} \\ 2.18\cdot10^{5} \end{bmatrix}\cdot Ci$$

Assign Deep dose DCF from nuclide file

$$DCF_{XE} := \begin{bmatrix} DCF_{dde_8} \\ DCF_{dde_7} \\ DCF_{dde_{10}} \\ DCF_{dde_9} \end{bmatrix}$$

"Xe-133
Xe-133m
Xe135
Xe135m

Set number of damaged assemblies

$K_{loca} := 193$ $\quad K_{lra} := 21$ $\quad K_{rea} := 97$

$$DCF_{XE} = \begin{bmatrix} 5.772\cdot10^{-3} \\ 5.069\cdot10^{-3} \\ 0.044 \\ 0.075 \end{bmatrix}\cdot\frac{rem\cdot m^3}{Ci\cdot sec}$$

For each accident, calculate the pseudo dose due to release of noble gases from a core with 4 MOX LTAs; and release of noble gases from a LEU core; compare differences in pseudo dose. Note that these are not "real" doses as parameters (such as X/Q, decay, flow rates) that are the same for MOX or LEU are not included.

LOCA

$$D_{mox} := \left[\left(C_{mox}\cdot4\right) + \left[C_{leu}\cdot(193-4)\right]\right]\cdot DCF_{XE}\cdot1.5 \qquad D_{mox} = 6.69\cdot10^{6}\cdot\frac{rem\cdot m^3}{sec}$$

$$D_{leu} := \left[\left(C_{mox}\cdot0\right) + \left(C_{leu}\cdot193\right)\right]\cdot DCF_{XE}\cdot1.5 \qquad D_{leu} = 6.574\cdot10^{6}\cdot\frac{rem\cdot m^3}{sec}$$

$$\frac{D_{mox} - D_{leu}}{D_{leu}} = 1.765\cdot\%$$

LRA

$$D_{mox} := \left[\left(C_{mox} \cdot 4\right) + \left[C_{leu} \cdot (21 - 4)\right]\right] \cdot DCF_{XE} \cdot 1.5 \qquad D_{mox} = 8.313 \cdot 10^{5} \cdot \frac{rem \cdot m^{3}}{sec}$$

$$D_{leu} := \left[\left(C_{mox} \cdot 0\right) + \left(C_{leu} \cdot 21\right)\right] \cdot DCF_{XE} \cdot 1.5 \qquad D_{leu} = 7.153 \cdot 10^{5} \cdot \frac{rem \cdot m^{3}}{sec}$$

$$\frac{D_{mox} - D_{leu}}{D_{leu}} = 16.222 \cdot \%$$

REA

$$D_{mox} := \left[\left(C_{mox} \cdot 4\right) + \left[C_{leu} \cdot (97 - 4)\right]\right] \cdot DCF_{XE} \cdot 1.5 \qquad D_{mox} = 3.42 \cdot 10^{6} \cdot \frac{rem \cdot m^{3}}{sec}$$

$$D_{leu} := \left[\left(C_{mox} \cdot 0\right) + \left(C_{leu} \cdot 97\right)\right] \cdot DCF_{XE} \cdot 1.5 \qquad D_{leu} = 3.304 \cdot 10^{6} \cdot \frac{rem \cdot m^{3}}{sec}$$

$$\frac{D_{mox} - D_{leu}}{D_{leu}} = 3.512 \cdot \%$$

These results confirm the adequacy of Duke's conclusion that the thyroid dose due to I-131 was an appropriate benchmark for their scaling of the previous UFSAR doses in establishing that the impact of the four MOX LTA on the LOCA, REA, and LRA is not significant.