MODELLING AND COMPARISON OF HOT CELL SHIELDING CAPABILITIES DURING A CRITICALITY EXCURSION

By:
Muhammad Akbar
Nuclear Safety Engineer
South African Nuclear Energy Corporation (Necsa)

14 May 2012

necsa
We're in your world

OVERVIEW

- Introduction
- Model Specifications
- Results
- Discussion
- Conclusion

INTRODUCTION

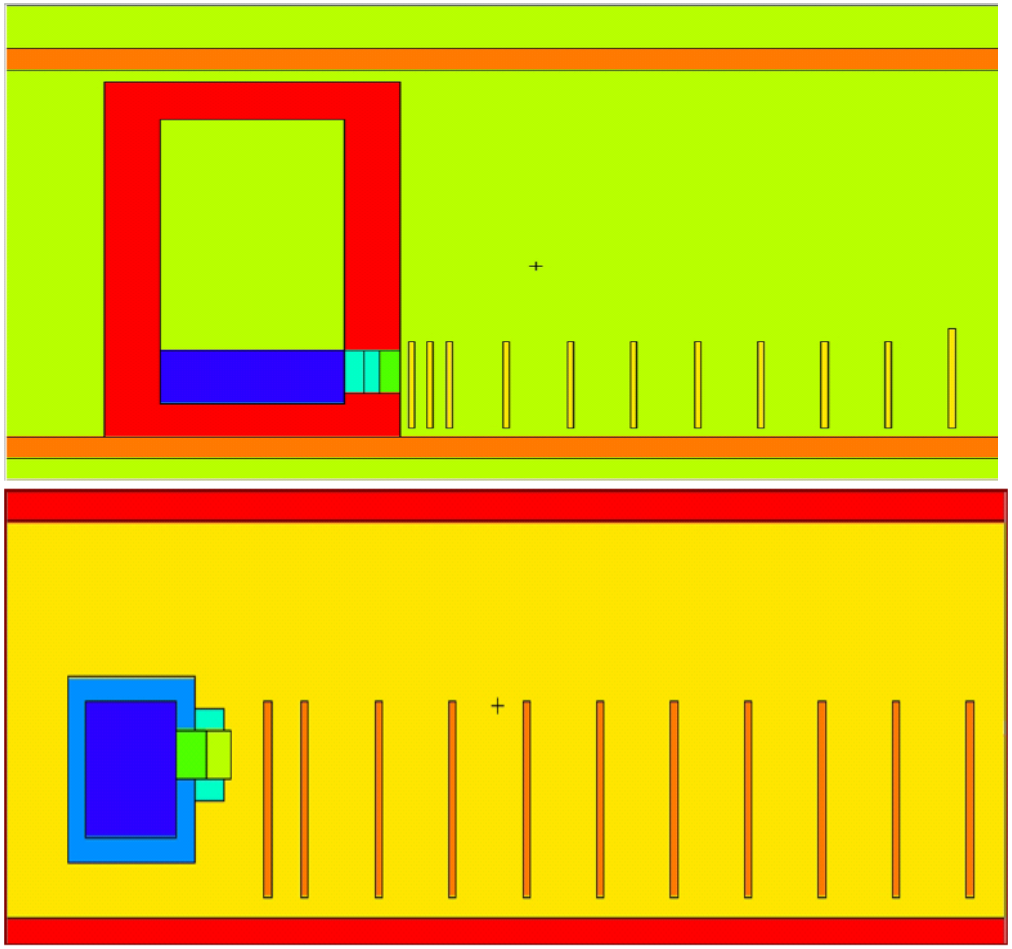
- What is Nuclear Criticality Safety?
  - Prevention or termination of inadvertent criticality
  - However the primary goal should be prevention

- Why look at Inadvertent Criticality?
  - To be aware of the consequences
  - To implement mitigation measures if possible
  - To minimize casualties

MODEL SPECIFICATIONS

- Monte Carlo code MCNPX 2.6 was used
- 25 cm lead vs. 87 cm magnetite high density concrete

MODEL SPECIFICATIONS



MODEL SPECIFICATIONS

- Monte Carlo code MCNPX 2.6 was used
- 25 cm lead vs. 87 cm magnetite high density concrete
- Moderator ingress accident with homogenous dispersion
- 20% enriched ^{235}U with k_{eff} between 1.01 and 1.03
- Detector-phantoms with tissue equivalent material

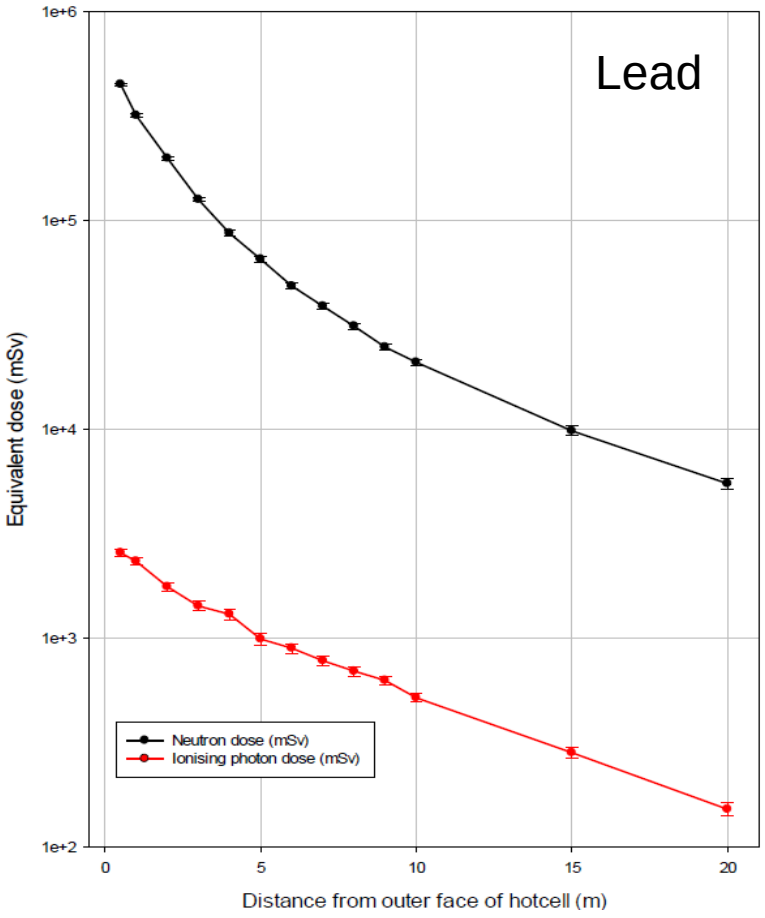
RESULTS

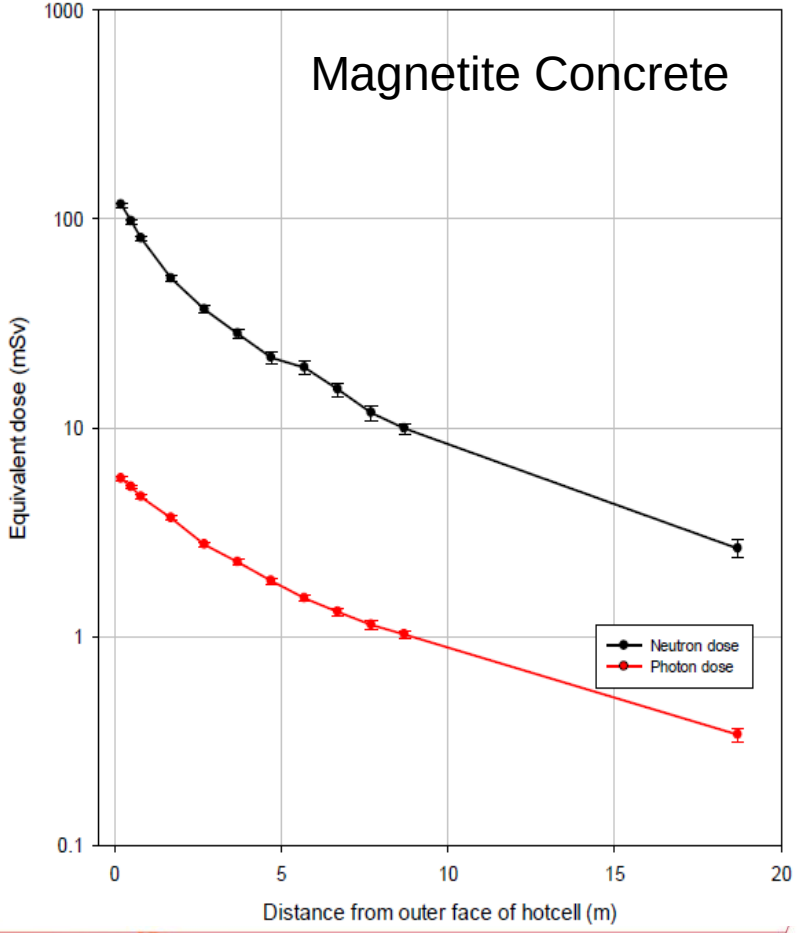
Total Equivalent Dose with 10^{19} Fissions			
Lead Shielded Cell		Concrete Shielded Cell	
Distance (m) from Hot Cell Outer Surface	Total Equivalent Dose (Sv)	Distance (m) from Hot Cell Outer Surface	Total Equivalent Dose (Sv)
0.5	451	0.5	0.1026
1	321	0.8	0.0853
2	200	1.7	0.0555
3	127	2.7	0.0396
4	88.3	3.7	0.0305
5	66.2	4.7	0.0235
6	49.4	5.7	0.0209
7	39.7	6.7	0.0166
8	31.9	7.7	0.0129
9	25.4	8.7	0.0109
20	5.6	18.7	0.0030

DISCUSSION

- Lead is a poor neutron shield
  - ^{208}Pb is a double magic number nucleus
  - However ionizing photons were attenuated efficiently
- Lead glass is a better neutron shield than lead
  - Attributed to the borosilicate content of the glass
- Magnetite concrete is an excellent neutron shield
  - Attributed to the hydrogen content
  - Also efficient in attenuating ionizing photons
  - Fewer secondary ionizing photons produced

ATTENUATION CAPABILITIES





CONCLUSION

- Design should cater for Inadvertent Criticality where appropriate.
- For hot cell operations involving possible criticality, consider high density magnetite concrete.
- Further modelling and investigation should be performed
  - To understand the exact relationship between lead and concrete
  - To take a wider variety of materials into account
  - To determine the impact of thermal neutrons

Thank You!!!