Assessment of dose rates due to a criticality accident - Influence of source and protections

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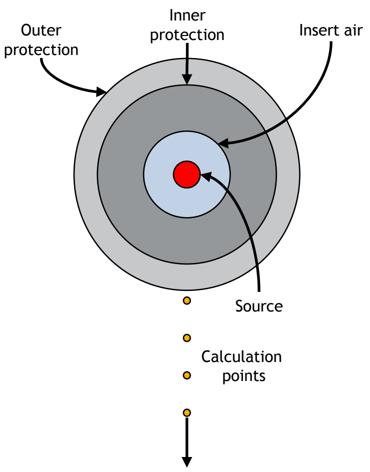
Context : In the event of a criticality accident, **exposure to ionizing radiations** of workers located close to the accident site **can be consequent**. Moreover, as in the case of the **Tokai-Mura** criticality accident (Japan, 1999), significant dose rates can be reported at large distances from the place of the accident (**several mSv.h^{-1} at several hundreds meters**).
The purpose of this poster is to present and analyse some **dose rates due to neutron and secondary gamma radiations** depending on different parameters (nature of **source**, nature of **biological protections**…).

Tools : As a technical support to the French Nuclear Safety Authority (ASN), the Institute for Radiological Protection and Nuclear Safety (IRSN) has developed an expert support tool, allowing to **quickly assess the dosimetric consequences in case of a criticality accident (CODAC as COnséquence Dosimétrique d'un Accident de Criticité) :**

- neutron, γ and total dose rate calculations
- variable configurations (source, shielding)
- up to 1 km from the location of the accident
- Variable number of fissions per second, and 2.874 neutrons per fission

Geometry : 1-D spherical



A few values of dose rates at 100 meters…

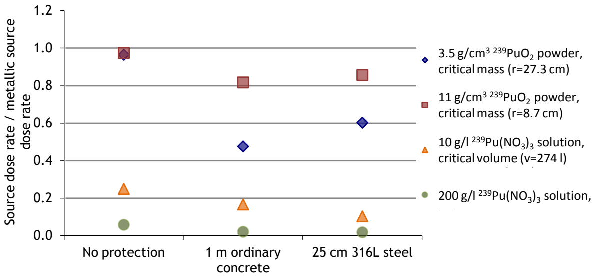
These dose rates are calculated for
5.10^{16} neutrons/s,
a typical value for a criticality accident.

After 1 m ordinary concrete :	*11.3*	*mSv.h^{-1}*
After 2 m ordinary concrete :	*20.9*	*µSv.h^{-1}*
After 1.4 m lead glass :	*174*	*mSv.h^{-1}*
After 62 cm lead glass + 1 m concrete :	*852*	*µSv.h^{-1}*

Large dose rates, even outside of plants

Influence of source

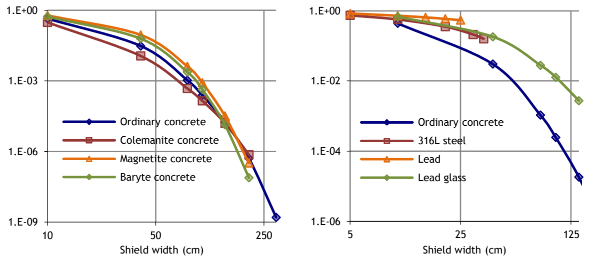
Calculations at 10 m from thicker protection, relative to metallic ^{239}Pu source (d=19.82):



- 11 g/cm^3 powder ≈ metallic source
- Strong impact of source **moderation** and **auto-absorption** over dose rate
- Supplemental moderation from concrete shielding (hydrogen abundant)
- 25 cm steel attenuates mainly γ -> low impact on total dose rate

Influence of protections

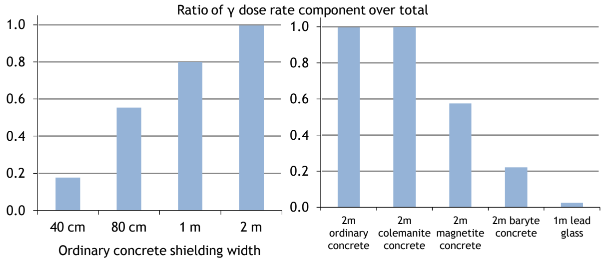
Attenuation factors for various shielding materials, estimated at 10 m from the center of source (200g/l $^{239}Pu(NO_3)_3$, 16 l), against naked source dose rate:



- Concretes by growing efficiency: magnetite, baryte, ordinary, then colemanite - reversal after around 140 cm width.
- At equal width, ordinary concrete more efficient than steel, lead and lead glass (strong neutron source)

Secondary gamma radiations component

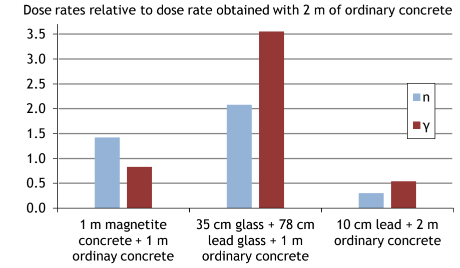
Calculations with metallic ^{239}Pu source (d=19.82) and at 10 meters from protection:



- With growing ordinary concrete width : growing attenuation of neutron flux, **dose rate mainly due to γ** after thick concrete shield (**outside of plants**)
- **Magnetite and baryte concretes better γ shields** than ordinary and colemanite concretes BUT neutron dose rates higher

Hot cells

Calculations for few **realistic two-layers shieldings**, estimated at 10 m from the center of source (200g/l $^{239}Pu(NO_3)_3$, 16 l):



- Presence of **viewing windows** in hot cells could cause **significant increase of dose rates** in some directions
- Added **lead layer** in hot cells allows **dose rates lowering** outside of plants