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Methodology to take into account polyethylene bags or containers

D. NOYELLES

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- **Introduction**
- **Methodology**
- **Some calculation results**
- **Extension of methodology**

Analysis of the influence of a non equal spherule size in fissile material

Study of environmental reflection : determination of the minimal distance between spheres of fractioned fissile material in a 2D infinite array

- **Conclusions**



• Introduction



• Methodology

HDPE moderation is taken into account as a moderator due to :

- > **vinyl plastics bags,**
- > **polyethylene containers.**

Generally, in nuclear facilities, polyethylene :

- > **is rarely fully mixed with fissile material,**
- > **often acts as an interstitial moderator between small masses of fissile media.**

Therefore, instead of considering a homogenous moderated fissile media with polyethylene : an infinite array of spherical heterogeneous dry (or nearly) fissile media in HDPE is modeled.

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• Methodology

S_n calculations are performed to determine permissible dimension (R), with full HDPE reflection, given the following parameters :

- > r_{spherule} : radius of spherical fissile material,
- > V_m/V_f : moderator-to-fuel ratio.

The ratio between the mass M of fissile material and the mass m of a single spherule can be defined as the number N of spherules in fissile material :

$$\text{Fractionation } N = \frac{M_{\text{fissile material}}}{m_{\text{single spherule}}} = \left(\frac{R}{r_{\text{spherule}}} \right)^3 \frac{1}{1 + V_m/V_f}$$

By varying spherule radius and moderator-to-fuel ratio, an array of curves representing fissile mass versus the fractionation can be constructed, leading to a bounding curve (M_{bounding} , N_{bounding}).



The results presented are only applicable in limited masses equipment

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• Some calculations results

Calculations results presented have been performed using the deterministic standard route of CRISTAL V1.2 criticality safety package.

Seven fissile media have been studied :

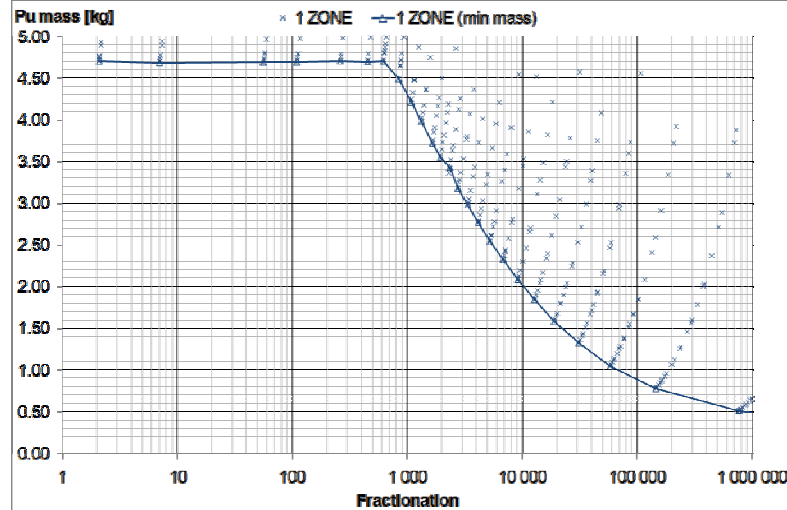
# fissile media	Physico-chemical nature	Density	Humidity [wt. %]	Pu isotopic composition	U isotopic composition		Pu/(U+Pu) [wt. %]
				²³⁹ Pu [wt. %]	²³⁵ U [wt. %]	²³⁸ U [wt. %]	
1	metal	19.6	0	100	-	-	-
2	metal	18.93	0	-	93.5	6.5	-
3	oxide	10,96	0	-	5	95	-
4	oxide	10,94	0	-	20	80	-
5	oxide	6.85	6	-	20	80	-
6	oxide	3.5	0	100	93.5	6.5	40
7	oxide	3.5	6	100	93.5	6.5	40



• **Some calculations results**

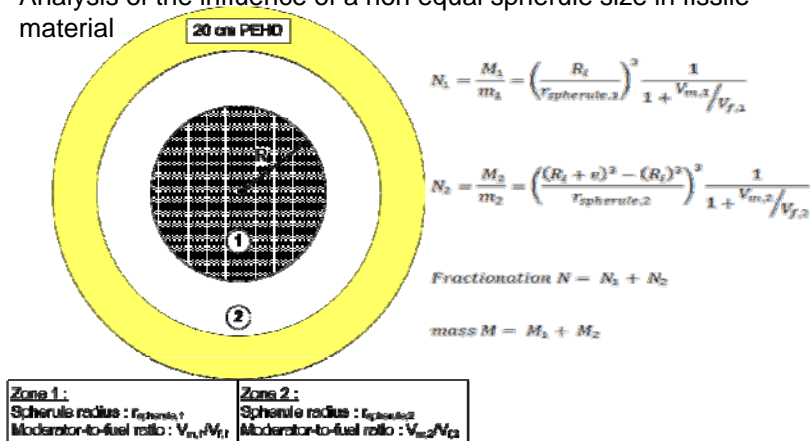
Fissile media 1 - Permissible mass versus fractionation

Pu metal - 100 % ^{239}Pu



• **Extension of methodology :**

Analysis of the influence of a non equal spherule size in fissile material



The results provided uses a genetic algorithm and convergence on the true Pareto front cannot be perfectly established.

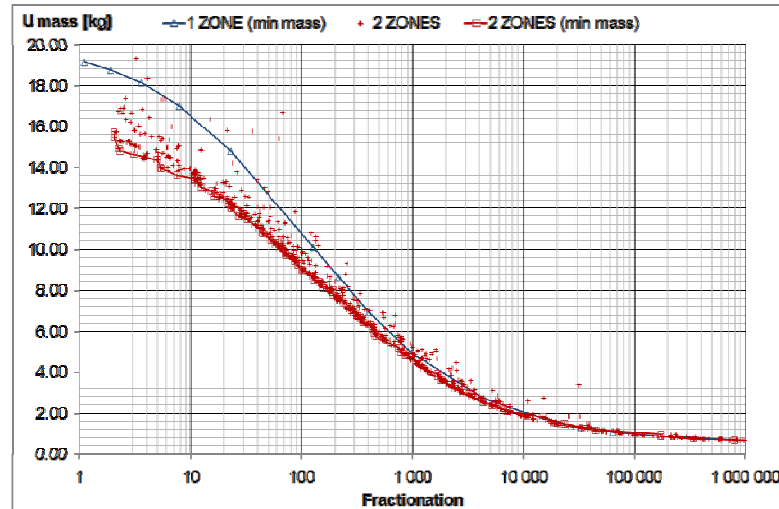
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• Extension of methodology :

Fissile media 2 - Permissible mass versus fractionation

U metal - 93.5 % ^{235}U

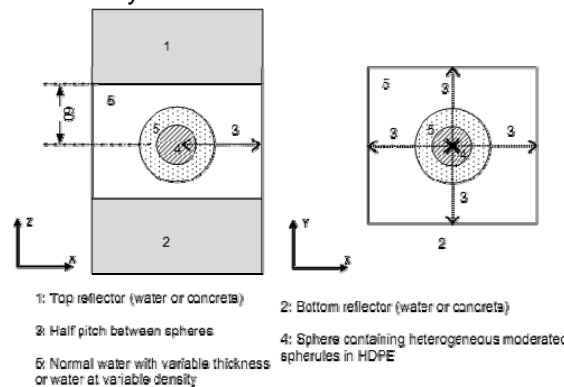


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• Extension of methodology :

Study of environmental reflection – Determination of the minimal distance between spheres of fractionated fissile material in a 2D infinite array



The distance between spheres of fractionated fissile material from where the multiplication factor doesn't vary is about 100 cm.



- **Conclusion**

When homogenous moderation with HDPE leads to unacceptable limitation, it is possible with the fractionation to :

- > **increase mass,**
- > **just control the number of items containing fissile material.**

It is not necessary to control the quantity of HDPE.

For example, pure metallic ^{239}Pu sphere reflected by HDPE and moderated with HDPE leads to admissible mass at $k_{\text{eff}}=0.95$ of 270 g instead of 400 g if moderated by water.

The fractionation corresponding to 400 g of ^{239}Pu need to maintain the number of items below 4 millions.



- **Thanks for your attention !**

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Fissile media 5 - Permissible mass versus fractionation
UO₂ oxide - 20 % ²³⁵U - Humidity 6 %

