





Means and procedures for stopping a hypothetical criticality accident in the MELOX homogenizer

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1. Presentation of the MELOX plant

Melox plant

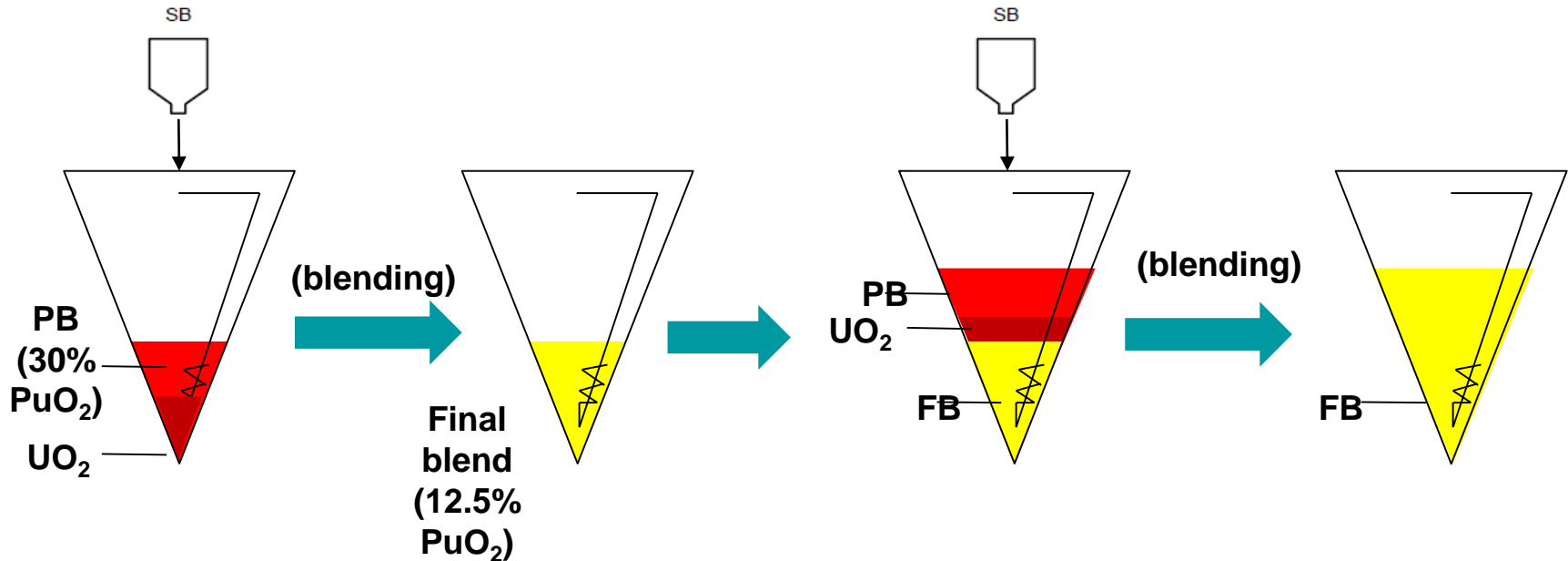
- ▶ Located in southern France
- ▶ Manufactures MOX fuel for light water nuclear reactors (PWR and BWR)
- ▶ Different areas : reception of nuclear materials, powder workshop, pellet workshop, rod workshop, assembly workshop and laboratory



General process



Homogenizer



7 jars of Secondary Blend in the homogenizer in order to form 700 kg of final blend



Criticality control mode : mass+ moderation (700 kg of MOX, 1% of moisture in the MOX)



2. Accidental scenario and how to stop the accident

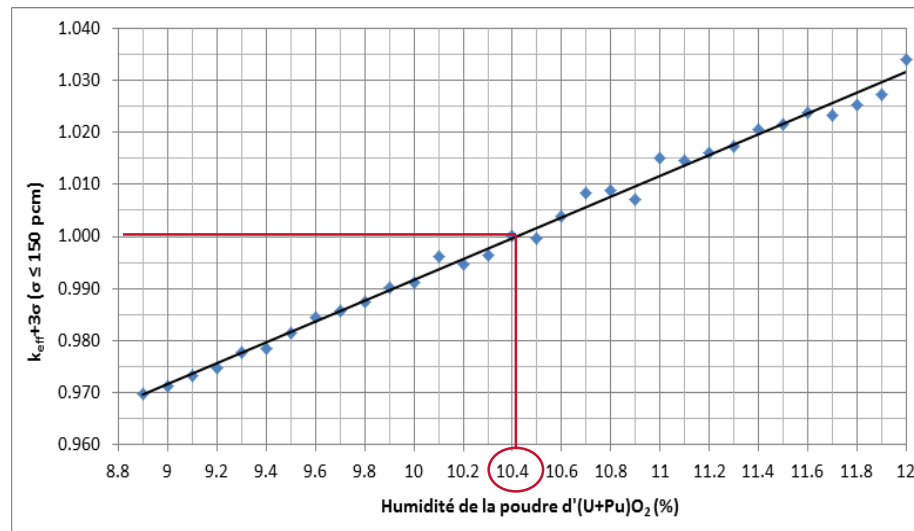
Chosen mean: use of Hafnium absorber

► Scenario

- Excess of moderation into the homogenizer ➡ accident
- Heterogeneous blend ➡ only 14 l of water can start an accident
- **Solution:** Start rotating the arm and screw, then homogenize the blend

► Minimal critical moisture

$k_{eff} + 3\sigma$ as a function of homogeneous moisture



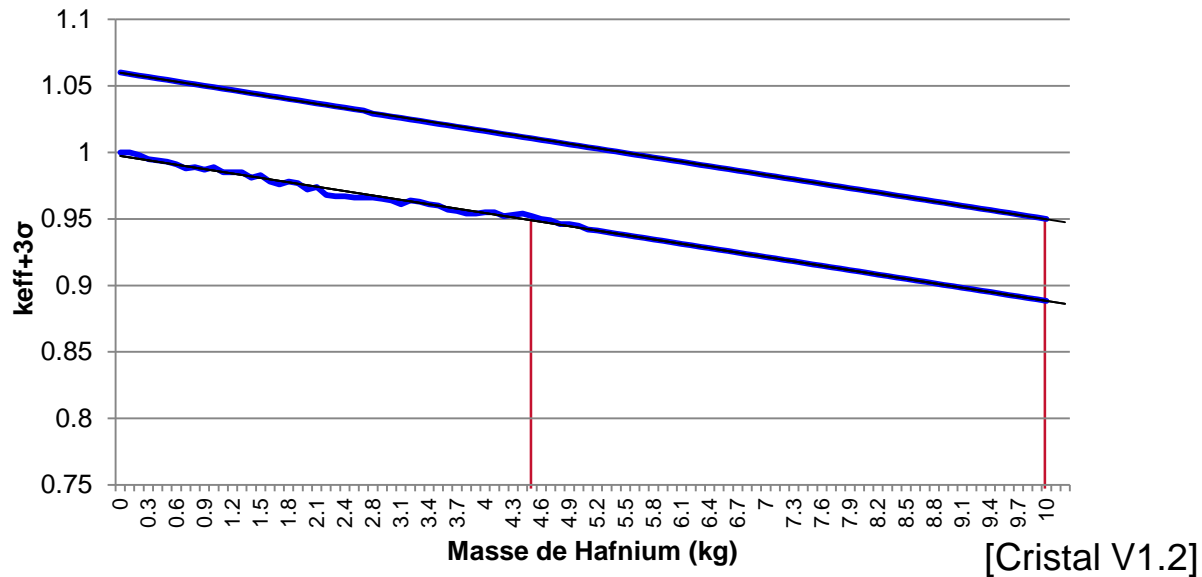
[Cristal V1.2]



Minimal critical moisture for 700 kg of MOX : 10.4 % ↔ **72 kg of water**

Chosen mean: use of Hafnium absorber

► Beyond 10.4% of moisture



10 kg of Hf is enough to stop any accident but it is decided to use 20 kg

**Chosen mean:
use of Hafnium absorber**

► **Conclusion**

- ◆ **First : homogenize the content of the homogenizer**
- ◆ **Then use 20 kg of Hf oxide, homogeneously distributed in the MOX**
- ◆ **These 20 kg of hafnium will be conditioned into 13 bags of 1.5 kg**



3 How to put the poison into the equipment?

Means for stopping a criticality accident

► Key points

Fill a jar with 20 kg of Hf oxide

- ◆ Define a locus where the dose rate is acceptable
- ◆ Control the dose rate at every time
- ◆ Optimize the operators' path

Steer the jar to NHX

- ◆ Define a control room with an acceptable dose rate
- ◆ Adapt this room so that it is possible to control the PLC
- ◆ Foresee PLC's alarms and inhibitions
- ◆ Définer means for avoiding these alarms and inhibitions

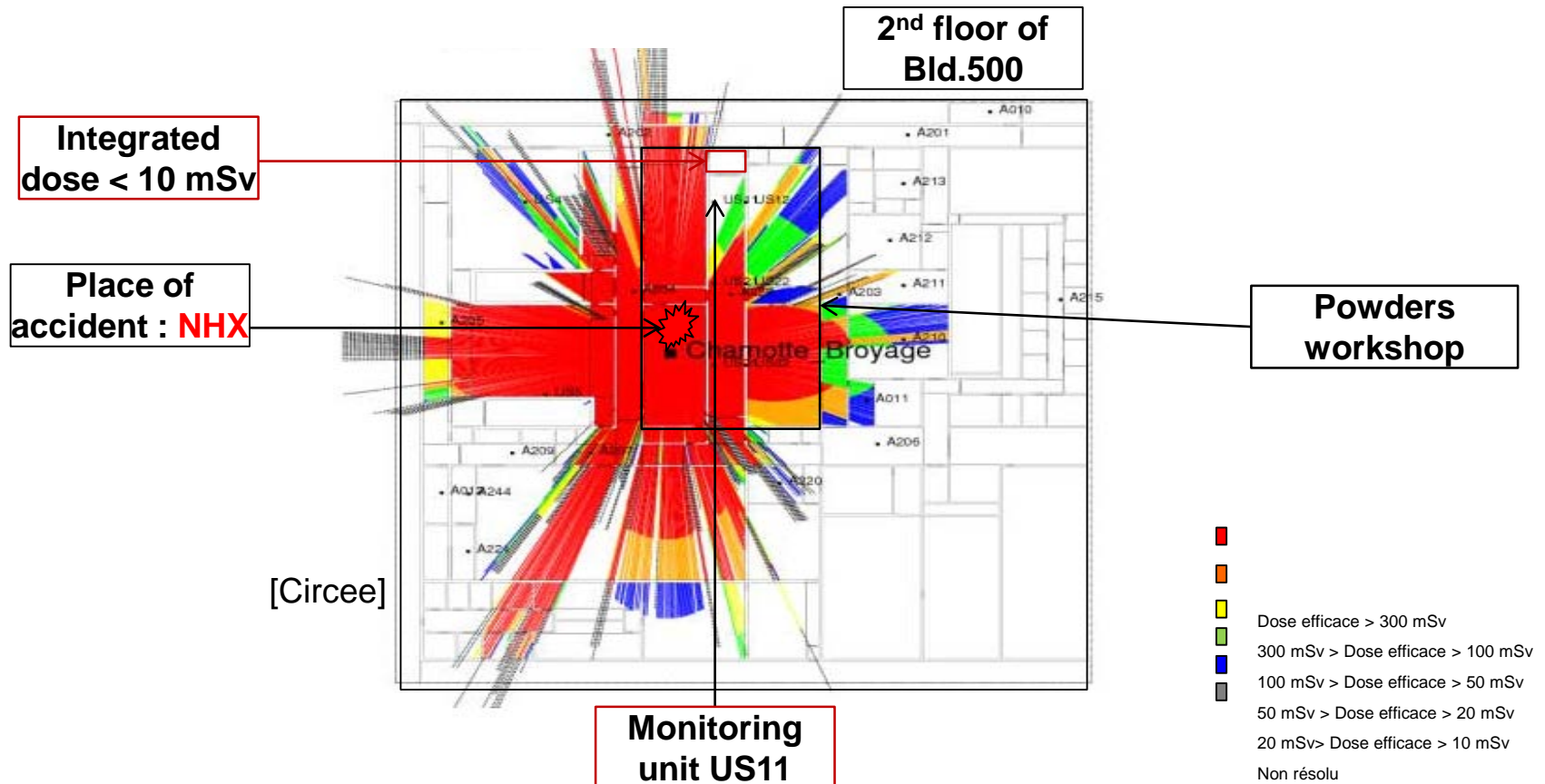


3.2.1 Issues and solutions about jar filling

Fill a jar with 20 kg of Hf oxide

Issues and solutions

► Locus of intervention

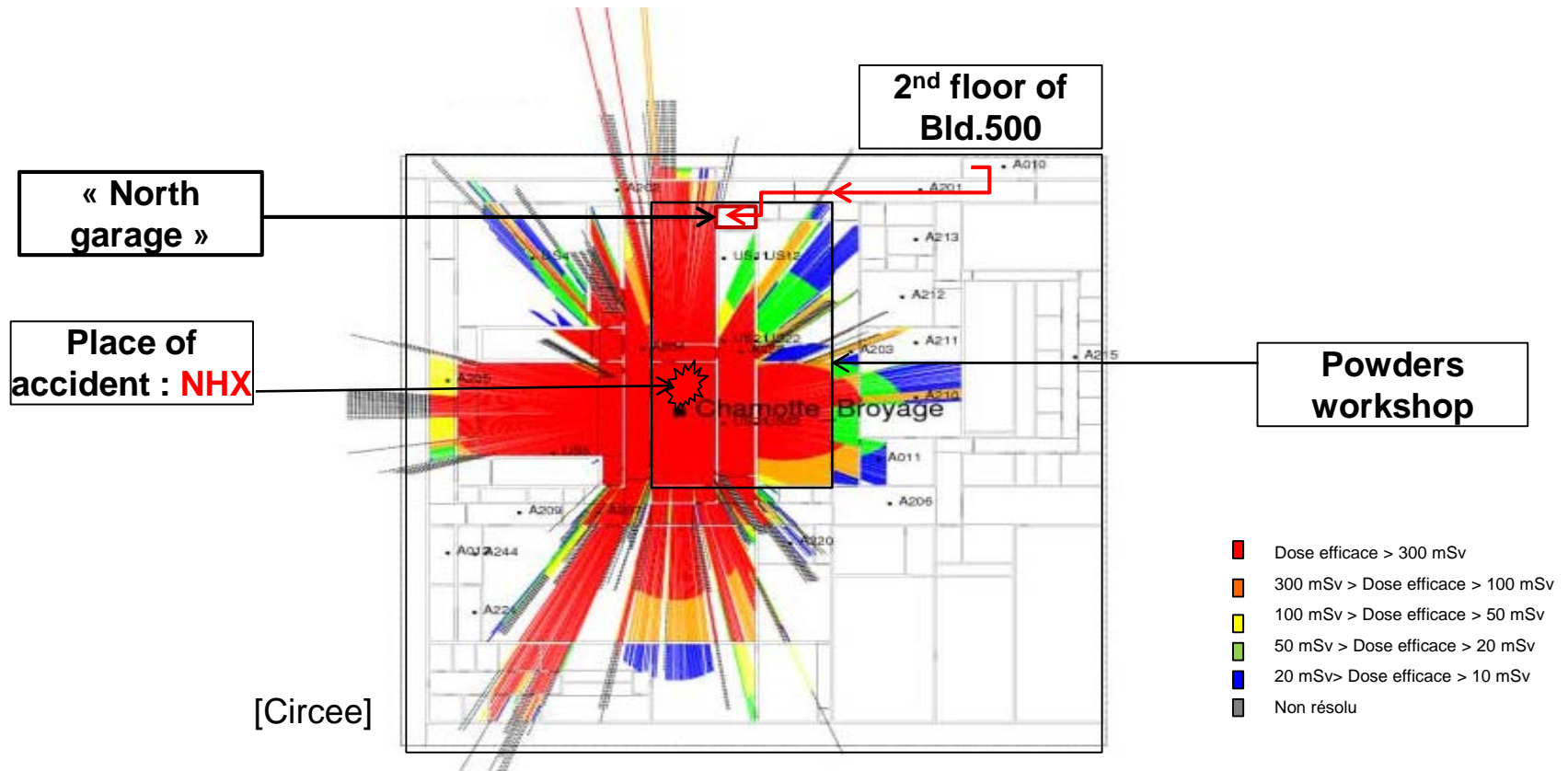


- Hf will be poured into a jar in the « north garage » of the tunnel on handling and storing
- 90 % of the integrated dose is due to neutrons: **Need of a neutron dose measurement => new neutron detector in this locus**

Fill a jar with 20
kg of Hf oxide

Issues and solutions

► Path to the locus of intervention

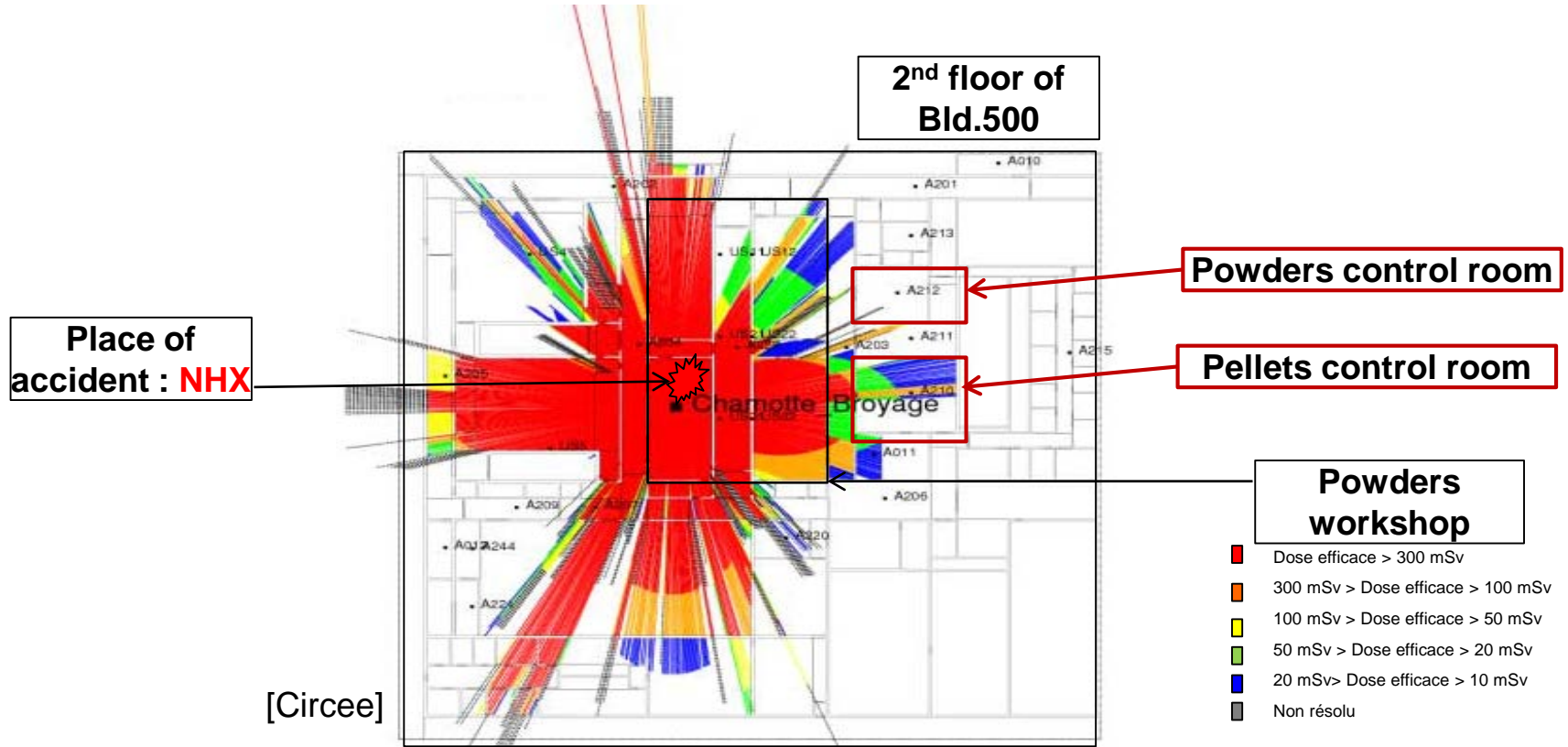


The chosen path minimizes integrated dose



3.2.2 Issues and solutions about jar steering

► Choice of a control room



- Potential doses are high - no dose monitoring in these control rooms
- It is necessary to find a more distant control room
- A distant room has to be equipped with the same control consols as in the powders control room

Jar steering : issues and solutions

► Identification of PLC and safety PLC inhibitions

2 PLCs will prevent the jar from entering the glovebox :

- The jar is not expected on the workstation
- The jar mass is different from a MOX jar



It is necessary to disable PLC and safety PLC

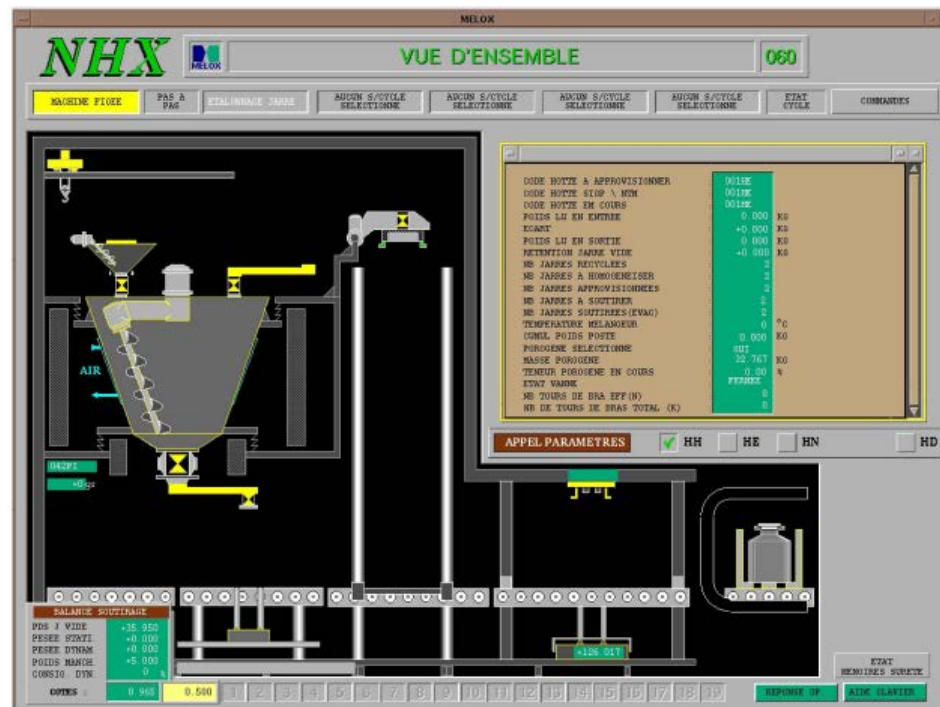
Some procedures have been written and have been used on a testing facility :
they are found to perform well

3.3 General procedure

General procedure

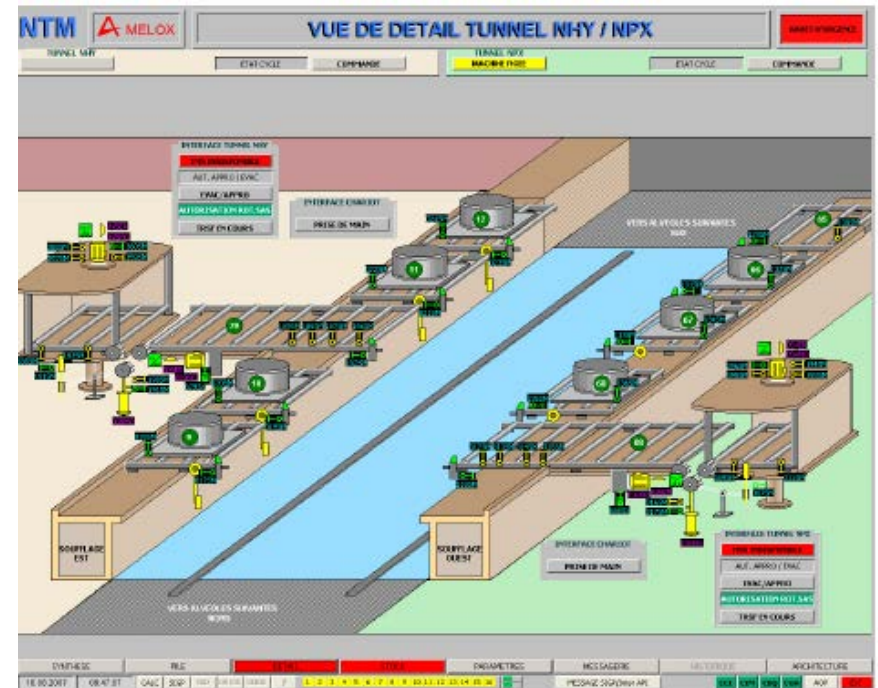
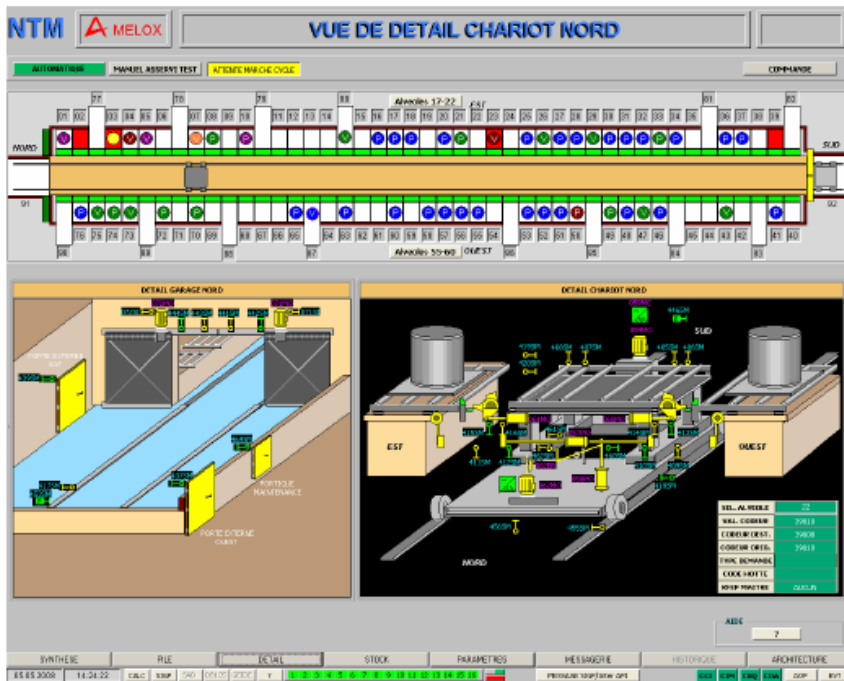
► First step

- ◆ Locate the place of the accident, using the γ and neutron monitoring system
- ◆ Load the HMIs of the homogenizer and the Tunnel of Handling and Storage on the controller in the distant control room
- ◆ Homogenize the content of the homogenizer



General procedure

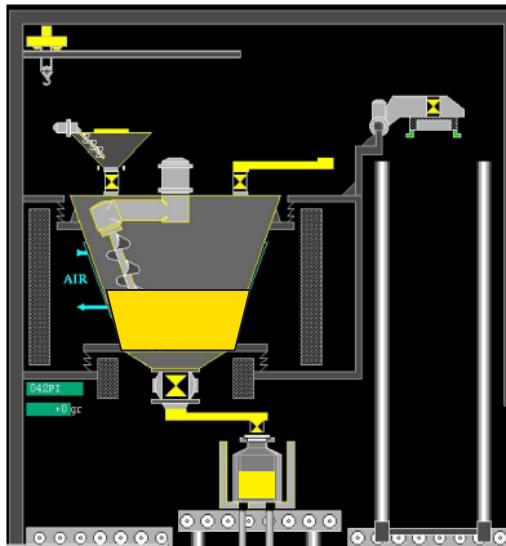
- HMI of the Tunnel of handling and storage



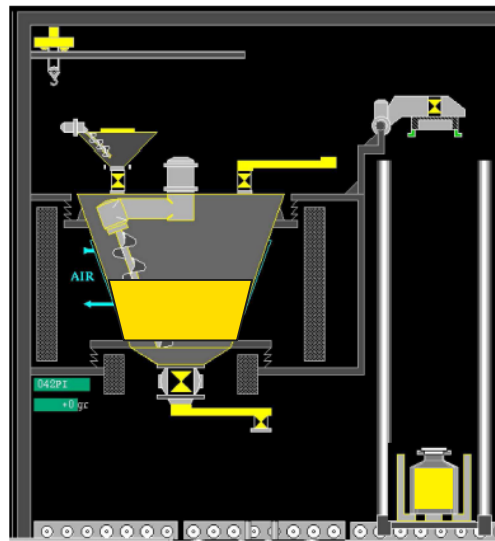
► Second step

- ◆ Analyse the workstation configuration

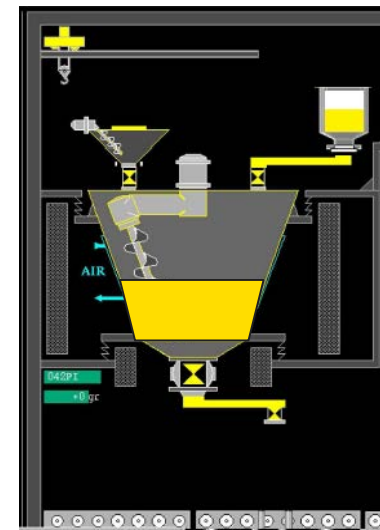
**Extraction to
a jar**



Supply or removal of a jar



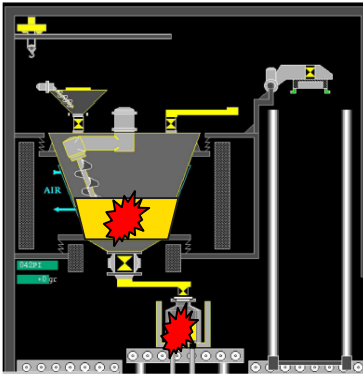
**Filling of the
homogenizer**



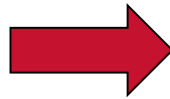
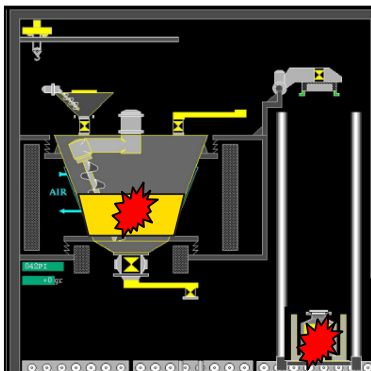
General procedure

► Localisation Of the accident

Extraction to a jar



Supply or removal



i) accident in the jar

or

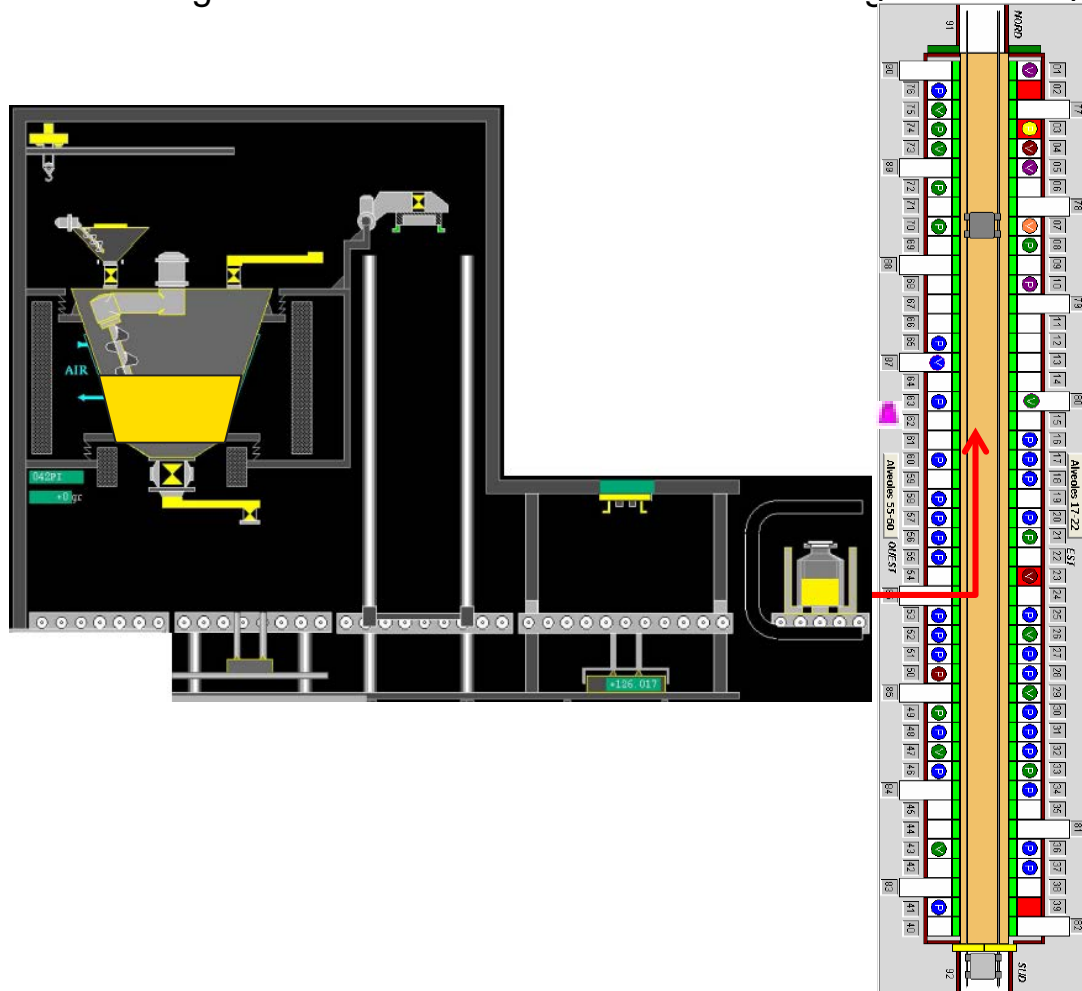
ii) Accident in the homogenizer tank

or

iii) both

General procedure

- ◆ Steer the jar next to a gamma detector in the Tunnel of Handling and Storage

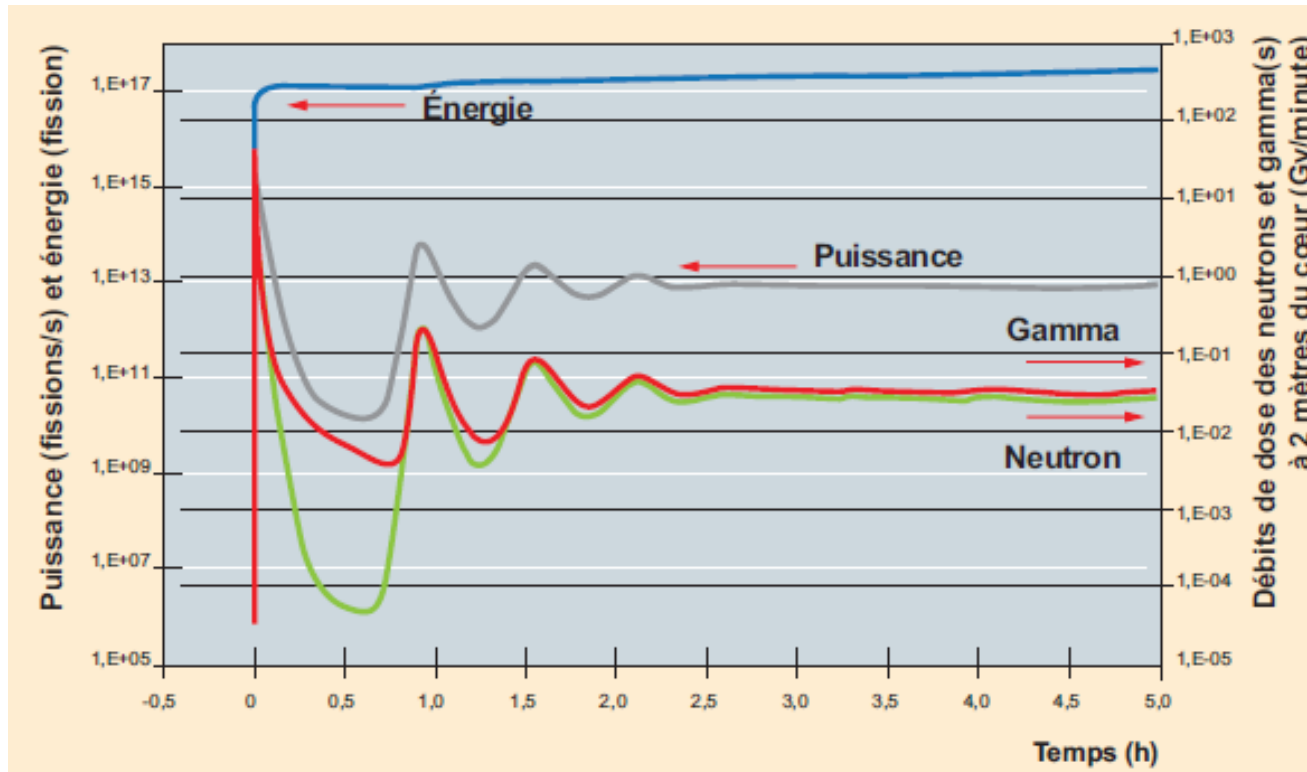


Gamma detector

General procedure

◆ Jar control

- In order to know if the accident took place in the jar or in the homogenizer, it is possible to check the gamma dose rate of the jar



[Silène experiment]



The dose rate after an accident is 100 times higher – if the dose rate is normal the accident is probably in the homogenizer tank

General procedure

- Dose rate from jar > « normal » dose rate and accident in homogenizer
 - Empty the jar into the homogenizer
- Dose rate from jar = « normal » dose rate and accident in homogenizer
 - Remove the jar to storage in a safe position
- Dose rate from jar > « normal » dose rate and no accident in homogenizer
 - Extract powder from NHX to new jars, and remove « safe » jars
 - Empty the jar containing the accident into the homogenizer

* Confirmation of an accident in the homogenizer is done by analysing measurements of the dose rate monitoring system near the homogenizer



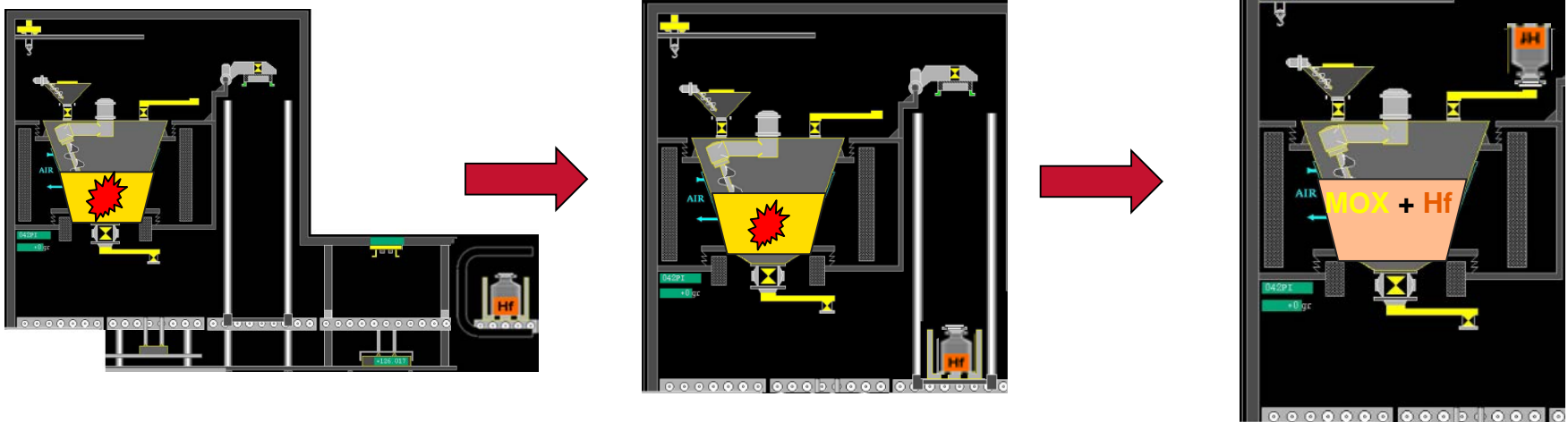
After this, the place of the accident is most certainly the homogenizer

General procedure

- ◆ Check the dose rate in « north garage »
- ◆ Take an empty jar and steer it to the « north garage » from a distant control room
- ◆ Put Hafnium into jar
- ◆ Disable PLC and safety PLC of the homogenizer
- ◆ Steer the jar to the homogenizer, using HMI from a distant control room

General procedure

- ◆ Pour the Hafnium from the jar to the homogenizer
- ◆ Rotate the arm and the screw of the homogenizer



5. Conclusion

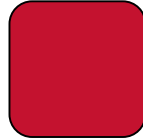
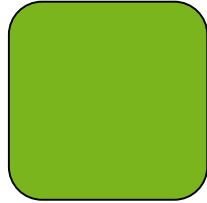
Conclusion

- ◆ **Necessity to use Hf if moisture ≥ 10.4 %**
- ◆ **Necessity to homogenize the content of the tank and to use 20 kg of Hf**
- ◆ **Control room : Has to be far from the accident**
- ◆ **Necessity to adapt another control room, far enough**
- ◆ **It is possible to put Hf in the homogenizer and stop the accident**
- ◆ **The procedure can be applied in case of accident on other powder workshop gloveboxes**

Perspectives



- ▶ **Perform some tests in order to check the homogenization of wet powders**
- ▶ **Define the conditions needed before authorizing free access to the building**



Thank you for your attention

