Accumulation of nuclear material in nuclear facilities an iterative approach in order to develop measuring stations

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1. Abstract

Measuring the deposits of nuclear material accumulated during processes in nuclear facilities is a major challenge in terms of safety and criticality. The characterization of the nuclear material, “holdup”, has to be taken into account since the design of new facilities, but also during their operation, and finally for the dismantling of historic equipment and facilities. Considering the diversity of encountered configurations, the holdup measurement is specific to each case. In this context, the Nuclear Measurement Laboratory of CEA Cadarache is specialized in developing and implementing gamma and neutron measuring stations, based on preliminary design and performance assessment by numerical simulation, then on iterative calculations taking into account the feedback of field measurements. In this paper, we illustrate this approach on different case studies, such as glove boxes in hot labs, covering the design, exploitation and dismantling phases of nuclear equipment and facilities.

2. Context and need

French and international safety authorities require that facilities using sensitive nuclear material (U, Pu, Th) guard against the risks of loss, theft and diversion of these nuclear materials [1].
Many solutions such as weighing, measurement, physical monitoring can meet this absolute need in operation. However, over time, the deposits of low amounts of nuclear materials that accumulate during processes in nuclear facilities, hot labs, hot cells, and glove boxes can lead to the retention of significant quantities of nuclear materials. This “holdup” has to be taken into account both in old installations, in order to dismantle them properly, in installations currently in operation, and preventively in installations under construction.
Therefore, measuring low amount of deposits of nuclear material is a major challenge. Today, the possibilities offered by non-destructive nuclear measurement provide solutions for many installations [2].

3. Contribution of the Nuclear Measurement Laboratory of CEA Cadarache on hold-up measurements

3.1 Analysis context and methodology

The Nuclear Measurements Laboratory (LMN) of CEA Cadarache is specialized in developing and implementing gamma and neutron measuring stations, based on preliminary design and performance assessment by numerical simulation, then on iterative calculations taking into account the feedback of field measurements.
In our methodology, the first step in designing such measuring stations, in a glove box or in a hot cell for example, is to establish the list of radiations emitted by the studied nuclear material in order to select the more suitable nuclear measurement.
This makes then possible to choose the sensor and the detection chain whose performances are the most adapted for a given configuration. For this, the laboratory relies on its long experience in nuclear gamma and neutron measurements, and photon imaging as well.
Finally, numerical modelling of the selected detector in its operating environment is carried out in order to determine, after several iterations, the optimal measurement configuration (type, size and position of the detector) and to define the sensitivity of the measurement (to different parameters such as the type, mass and distribution of nuclear materials).

3.2 Recent examples of measuring stations design by the LMN

Our lab is solicited for different studies ranging from the simplest case of new installations, where the design of the measurement system is open, to the most difficult case of historic installations, where it is necessary to adapt to existing implementation constraints, and to more or less known history leading in some instance to poor knowledge on nuclear materials.
The two examples below illustrate both cases.

The first situation is concerning a hot cell under construction where nuclear material will be reconditioned. The nuclear material is well known, the geometry of the equipment is still modifiable. The choice and the position of the detector can be optimized by successive numerical modelling comforted by experimental campaigns.

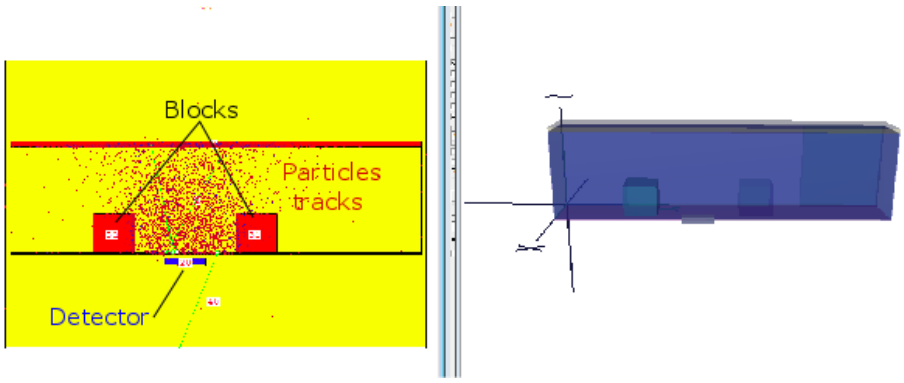

Figure 1. Numerical modelling of a holdup measuring station for a reconditioning glove box.

The second case concerns an old equipment used to characterize nuclear materials. This equipment had to be moved in a safe way. In this case, numerical simulation has been used in order to select the best measurement configurations. Then experimental results have been interpreted using numerical simulation to obtain quantitative results on the nuclear material hold-up.

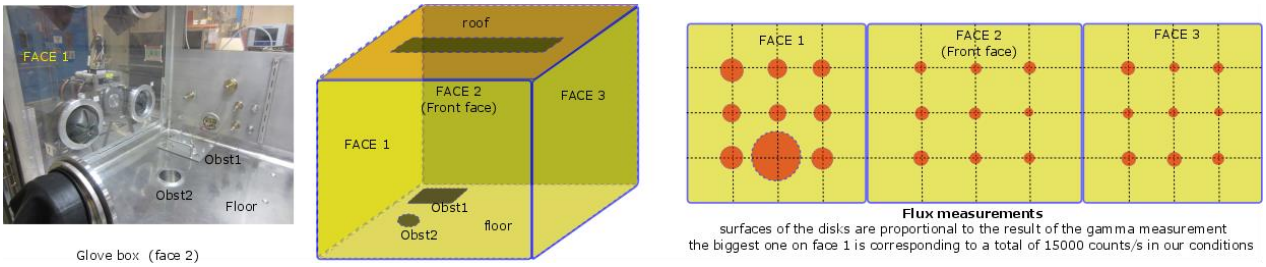

Figure 2. Measurements and quantitative results for holdup in an equipment in view of its transport.

The methodology used by our lab for those cases can easily been applied to other situations.

References

1. ”Passive Nondestructive Assay of Nuclear Materials” - United States Nuclear Regulatory Commission

2. “Nuclear safeguards, security, and non proliferation“ - Los Alamos National Laboratory BUTTER-WORTH HEINEMANNHOMELAND Security series.