CONTROLLING THE ALPHA RISK

IN THE EDF FACILITIES

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0) Foreword

Due to the characteristics of the radiation they emit, alpha emitters are highly radiotoxic in terms of internal exposure but their low penetration makes them inoffensive in terms of external exposure. This toxicity is clearly shown in the table below, which compares the equivalent dose resulting from the ingestion of 1 Bq or 1µg (10^{-6} g) of a few radionuclides commonly found in nuclear power plants:

Radionuclide	Type of emission	Equivalent dose due to the ingestion of 1 Bq	Dose equivalent to the ingestion of 1µg
Plutonium 239	α	140 µSv	0.32 Sv/µg
Curium 244.	α	76 µSv	21.71 Sv/µg
Americium 241	α	140 µSv	17.5 Sv/µg
Cobalt 60	β+γ	0.06 µSv	2.46 Sv/µg
Cesium 134	β+γ	0.013 µSv	0.54 Sv/µg
Iodine 131	β	0.008 µSv	33.75 Sv/µg
Tritium	β	0.000016 µSv	0.01 Sv/µg

In PWR power plants, α emitters are rare and the risk of contamination is particularly low. Until now, this risk has always been well controlled by the operator, and is not one of the main Radiological protection priorities within EDF.

Nevertheless, requirements are always increasing, whether for the radiological protection of workers or the public, and have led EDF to reconsider the α risk, to ensure that the current provisions are adequate and to reinforce them if necessary.

Therefore, a study of the α risk was started in 1999.

1) The production of a emitters in PWRs

The existence of alpha emitters in the primary cooling system has various origins:

- the main source of contamination is associated with the damage of fuel during operation. If the faults are serious enough, physical damage and erosion of uranium oxide in contact with the primary coolant may occur.
- to a lesser extent, alpha emitters are due to the activation of the small quantities of fissile material on the fuel rods before loading. The presence of such fissile material is associated with residual contamination of cladding in the factory, or with the presence of natural Uranium in the cladding material.

These fine particles in suspension in the primary coolant are deposited fairly quickly, mainly in heat exchange areas and on the surface of fuel rod cladding, but also in dead legs, filters and walls.

The particles deposited on the walls of the primary cooling system are diffused within the layers of oxides and are fixed on them. Under such conditions, only part of the actinides is retained by the purification circuit, the other part remains in the components of the primary cooling system and is likely to be released during maintenance work, long after the initial pollution.

We must therefore distinguish between two types of contamination of the primary cooling system:

- that of the fluid itself, which is monitored by the radio-chemical monitoring of the water of the primary cooling system:
  - the presence of iodine 134 is a good indicator of the presence of fissile material,
  - the α contamination of the primary cooling system which is measured periodically.

- that of the walls of the primary cooling system out of flow[1], which builds up during the life of the power plant, by "the memory effect" of the layers of oxides, and which therefore depends as much on the history of the unit and the faults which occurred during previous cycles, as the state at of the fuel cladding in the current cycle.

There is therefore a risk of internal exposure of workers working on components of the installation.

[1] "In flow" contamination is eliminated during the replacement of fuel

2) Prevention of the a risk for workers

The real goal for EDF is to not create internal α contamination of workers.

In view of that described above, the risk of contamination is mainly due to maintenance and dismantling work, when, during such work, the layers of oxides in the circuits in contact with the primary coolant are subject to mechanical attack (by grinding, cutting, etc…) or when the surface contamination is resuspended by the ambient air scavenging of non fixed particles.
Such dust may be :

- ingested or inhaled directly by workers if they are not equipped with personal protection (helmet or ventilated clothing, etc.),
- or deposited on others parts of the installation if the work site is not confined, thus extending the area at risk of contamination.

Not all facilities have the same level of potential alpha risk. This risk is directly associate with the operating history of the installation and the nature of the work to be carried out.
We estimate that for PWRs, the average level of surface contamination of circuits in alpha emitter radionuclides is between 0.5 and 1 Bq/cm².

3) Type of monitoring adopted by EDF

EDF has decided to acquire a systematic installation monitoring system with three levels of investigation:

1) monitoring of the primary cooling water and pools in operation, as an initial alert indicator and to anticipate the special provisions to be taken,
2) monitoring at the start of a unit shut-down, of certain highly exposed surfaces of the installation particularly to determine whether an α risk is to be taken into consideration more extensively,
3) if the second level is positive, monitoring the possible α contamination of work site likely to be contaminated.

For the first level of monitoring, an Iodine 134 activity threshold and an alpha activity measurement of the primary coolant or of the spent fuel pit enables the risk of α contamination to be anticipated before the next shut-down. The shut-down is therefore prepared by taking the special provisions into account and we may revise such provisions if the contamination is not finally confirmed.

The second level of monitoring consists of radiological protection measures against labile alpha contamination (unstable) on surfaces not directly in contact with fuel elements but in contact with the primary coolant, such as the pressurizer and the reactor vessel head.
Such surfaces correspond to sensitive areas, which represent the maximum contamination of the installation. This level of monitoring is also used to take the history of the installation into account.

An installation is declared to be "at alpha risk" when the radiological protection measures reveal labile alpha contamination greater than 8 Bq/cm². This value corresponds to the resuspension of labile surface contamination of Am 241, leading to atmospheric contamination of 1 LDCA when the resuspension factor is equal to 10^{-6} m^{-1}.

Where second level monitoring is positive (>8 Bq/cm^2), that is the installation is considered to be "at alpha risk", third level monitoring is started and consists in checking for the presence (or not) of alpha contamination on all parts of the installation contaminated by activation products (rooms, equipment, ventilation, etc.).

Under such conditions, routine prevention provisions against internal exposure are taken and personal and collective protection equipment are used.
Special attention is paid to grinding work which requires the systematic use of prevention devices. Therefore, for installations being dismantled and maintenance workshop, the activities of which include grinding work, the provisions taken for the confinement and protection of workers are applied systematically.

4) Implementation and information feedback

The principles and provisions described above were implemented in the Cattenom plant, in particular during the shut-down of unit No. 3 in 2001 and were found to be totally satisfactory.
