Self-charging of radioactive dust and its bearing for nuclear safety

M. Sow[a], G. Dougniaux[a], S. Peillon[a], C. Grisolia[b], A. Autricque[b], P. Lemaitre[a], S. Bourrous[a], F. Gensdarmes[a]
[a]Institut de Radioprotection et de Sûreté Nucléaire (IRSN), Gif-sur-Yvette, 91192, France
[b]CEA, IRFM, Saint Paul Lez Durance, 13108, France

***Abstract*—The presence of dust particles in nuclear plants and laboratories is of highest safety threat because of the radionuclides they incorporate. More specifically, in case of accidental release, airborne radioactive dust is a dominant pathway for human contamination through inhalation, ingestion and skin deposition [1]. Furthermore, the finest size fraction ranging from few nanometers to few micrometers in diameter can be transported over extended distances to contaminate lands and oceans [2]. Because of the nuclear decay, radioactive dust particles naturally self-charge, making them eligible for electrostatic interactions which unescapably affect their dynamics [3]. In view of that, IRSN has launched a series of experimental and simulation research activities in which dust electrical charge is carefully well-thought-out. A special effort is directed to the development of experimental benches to assess among others: the dust adhesion forces on the upcoming ITER Tokamak first walls, the dust filtration efficiency in the containment barriers of nuclear facilities and the dust removal from the atmosphere by precipitations. A noticeable outcome considering the potential self-charging of tritiated tungsten dust in the ITER vacuum chamber for instance is how the presence of a thin oxide layer on tungsten dust particles surface alters their permittivity by reversing their electrical properties from conductive to insulating. This latter will result on particles accumulating charges over time, promoting electrical adhesion forces. The consequence of which, for a monolayer deposit, should be a strengthening of the oxidized dust adhesion to the surfaces in presence of air, and a lessening of their hazardous mobilization by aerodynamic forces [4]. Investigations on dust removal efficiency by raindrops reveal substantial influence of dust electrical charge, especially for particles of size in the Greenfield gap region at about half-micron diameter. Regarding the washout of radioactive self-charged dust in a nuclear accident scenario, overlooking the radionuclides electrical charge may lead to an underestimation of model soil contamination calculations and a misestimating of health threats [5]. In parallel with the experimental investigations, simulation calculations are currently deployed to better apprehend the self-charging rate of radioactive dust, in particular the β emission of tungsten and beryllium particles absorbing tritium. In the same vein, rigorous estimation of the electrical adhesion forces for particles deposited on a conducting surface using finite element analysis method is performed.**

REFERENCES

[1] Eckerman, K. F., Wolbarst, A. B., & Richardson, A. C. (1988). Federal guidance report No. 11 (No. EPA-520/1-88-020).
[2] Adachi, K., Kajino, M., Zaizen, Y. & Igarashi, Y. (2013). Scientific reports, 3, 2554.

[3] Gensdarmes, F., Boulaud, D. & Renoux, A. (2001). Journal of aerosol science, 32(12), 1437-1458.
[4] Peillon, S., Sow, M., Grisolia, C., Miserque, F. & Gensdarmes, F. (2017). Journal of Electrostatics, 88, 111-115.
[5] Sow, M., & Lemaitre, P. (2016). Annals of Nuclear Energy, 93, 107-113.