Numerical Modeling of Sampling Airborne Radioactive Particles Methods From the Stacks of Nuclear Facilities in Compliance with ISO 2889

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Abstract

The International Standard ISO 2889 focuses on monitoring the activity concentrations and activity releases of radioactive substances in air in stacks of nuclear facilities and sets the performance criteria and recommendations required for obtaining valid measurements.

The goal of achieving an unbiased representative sample is best accomplished where samples are extracted from a location where the radioactive materials of interest are well mixed within the free stream. The criteria that guarantee the homogeneity of the air stream at the sampling locations are the following:
• absence of angular or cyclonic flow (the mean flow angle between the flow axis and stack axis should not exceed 20°);
• symmetry of air velocity profile (the coefficient of variation should be less than 20% on the centre two-thirds of the area of the stack);
• symmetry of gas concentration and particle profile, injected on the base of chimney (measured with the same principle of velocity profile).

In circumstances where the well mixed criteria are not achieved, a multi-nozzle probe (instead of a single nozzle probe) can be required to get a representative sample.

During off-normal conditions, the performance of the sampling system can be affected by the modification of several parameters (temperature, flow rate in stacks, type of airborne particles). In any case, acceptance criteria described in the International Standard for normal conditions still apply for off-normal conditions and an evaluation of the opportunity to use a special or separate air sampling system is needed.

The main objective of this study is to verify the compliance of an ongoing nuclear facilities stack design with the ISO 2889 requirements, during normal and off-normal conditions. In particular, with the numerical simulations, they have been identify well-mixed sample locations along the chimney and the compliance with the International Standard requirements as result of stack flow rate and airborne particle aerodynamic diameter modifications.

The 3D simulations have been performed with COMSOL Multiphysics® version 4.4 (Heat

Transfer and Particle Tracing Modules). The stationary simulations are based on the following segregated steps: fluid flow study (single-phase incompressible turbulent k-eps-wall function model), transport of diluted species study and particle tracing study (Lagrangian approach).

The results presented in this study confirm the capability of COMSOL Multiphysics® as a multiphysics simulation tool. The development of this work has allowed us to obtain useful indications for the nuclear facilities stack design, reducing the field testing costs.