PREFACE

NUCLEAR AEROSOL SCIENCE

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Nuclear aerosol science dates back to mid-1960 when first estimates on aerosol behavior in vessels were investigated for the safety analysis of fast breeder reactors. Experiments on nuclear aerosol behavior at that time initially indicated the need for aerosol behavior modeling, which was only in a rudimentary state. Most information available at that time was in the areas of aerosols in mining, industrial processes, and natural radioactive aerosols only. Because the aspects of nuclear aerosols were different compared to "environmental" aerosols, mainly due to higher concentrations and extreme thermodynamic boundary conditions, the term "nuclear aerosols" was coined. The first international specialists' meeting on nuclear aerosols took place at Karlsruhe, Federal Republic of Germany (FRG) in 1969 (Ref. 1).

A considerable amount of technical knowledge and basic scientific information has been developed in the last 20 years. Nuclear aerosol science was always embedded in the fast-growing field of reactor safety research, which is closely linked to nuclear aerosol research, because of the dependence of nuclear aerosol behavior on accident scenarios, thermodynamic boundary conditions, and the design and performance of containment systems of nuclear power plants. Initial research concentrated mainly on sodium, plutonium, and uranium aerosols, which may play a role in accidents of liquid-metal fast breeder reactors (LMFBRs) or in spent-fuel reprocessing plants,[2] due to the possible formation of aerosols in accidental burning of sodium and metal fuel. Beginning in the mid-1970s, nuclear aerosols from light water reactors (LWRs) also became a subject of research, when the investigation of core-melt accidents in LWRs drew strong attention from several nuclear aerosol research groups.

Nuclear aerosol science was also intensively related to basic scientific questions of aerosol physics, aerosol chemistry, and aerosol measurement techniques. From the relatively crude aerosol behavior models used in early investigations to the sophisticated aerosol codes used today for worldwide nuclear accident analysis and risk assessment, a large amount of scientific and technical information and experience has been accumulated, both theoretically and experimentally. In particular, the significance of phoretic aerosol processes in aerosol codes was clarified; the importance of the close coupling of thermodynamics and aerosol dynamic behavior was identified; and the chemical characterization and the physical parameter measurement techniques for nuclear aerosols were greatly improved. Also, the performance of simulation experiments in small- and large-scale vessels (or other structured volumes) was a typical element of nuclear aerosol research, mainly to support nuclear aerosol behavior modeling.

Unfortunately, published nuclear aerosol research information is widespread in various journals and conference and research reports. However, a group of experts of the Nuclear Energy Agency Committee on the Safety of Nuclear Installations (CSNI) published a state-of-the-art report on nuclear aerosols in reactor safety[3] in 1979 and in 1985 a supplement to the 1979 report[4] that discussed the relevant aspects of nuclear aerosol information available at that time. In particular, state-of-the-art information on aerosol formation and characterization as related to the radiological source term, on the aerosol processes and behavior inside the containment system, and on the computer modeling of aerosol processes inside the containment (aerosol codes) were evaluated and described. These activities were closely linked to the international CSNI specialists' meetings on nuclear aerosols in reactor safety in Gatlinburg, Tennessee, in 1980 (Ref. 5) and in Karlsruhe, FRG, in 1984 (Ref. 6).

This special issue on nuclear aerosol science is intended to describe the state of the art in a series of original contributions from the majority of groups working in the field. Major progress, particularly in the areas of nuclear aerosol experiments, nuclear aerosol codes, emergency filtration of nuclear aerosols, and nuclear aerosols and radiological source terms is reported to give a comprehensive view of recent achievements in nuclear aerosol science in general, but also referring to open problems and questions for both LWR and LMFBR applications. Aerosol codes and large-scale testing of nuclear aerosol behavior can be considered as important tools in nuclear aerosol research. It has been shown that aerosol behavior and removal from containment atmospheres can be satisfactorily calculated by computer models that are experimentally verified. The strong relation of aerosol behavior and removal to the radiological source terms of nuclear power plants has been identified. Aerosol formation and depletion processes, including the engineered safeguardlike air-cleaning devices, are now considered to be the decisive factors in the assessment of radiological source terms of nuclear power plants.

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