THE NRC’S REVISED ACCIDENT SOURCE TERM

Background

Following the accident at Three Mile Island, the U.S. Nuclear Regulatory Commission (NRC) undertook a significant research effort to better understand reactor accidents that go beyond the design bases of U.S. nuclear power plants [Ref. 1]. That effort was initially directed at obtaining a more realistic source term for the radionuclides to be used in safety analyses of nuclear power plants. At the time, the so-called “TID-14844 source term” [Ref. 2] was used for less-severe design-basis safety analyses. This source term, which was devised in the 1960s, hypothesized that “severe” accidents would produce a source term of radionuclides to the reactor containment, which would primarily be composed of noble gases and iodine in gaseous form. However, events during the accident at Three Mile Island suggested that this characterization of radionuclide release to the containment might be overly conservative, in that iodine released to the containment would not be entirely in gaseous form. Further, the complete release of radioactive material to the containment was not instantaneous, as was hypothesized in the safety analyses. The outcome of this aspect of the NRC’s research program has been a revised source term for use in reactor safety analyses [Ref. 3].

The effort to understand severe accident phenomena evolved with time to provide general technical support for the development of a technical understanding of severe accidents for use in probabilistic risk assessments. In this evolution, the undertaking built upon the mechanistic modeling of accident phenomena, loads on reactor containments, and radionuclide behavior, as developed for the “Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants” (WASH-1400) [Ref. 4], which addressed residual risks posed by the use of commercial nuclear power reactors. Support for the analysis of accident progression and fission product release has become especially important as the NRC modifies its reactor regulations to become more risk-informed and performance-based.

The objective of the NRC’s research activities in this area is to develop computer models of accident processes and fission product releases, which can be used to make predictions for the wide range of accident conditions considered in risk assessments. Toward that end, the NRC has developed a systems-level modeling tool, known as the MELCOR integral severe accident analysis code, which addresses all important phenomena in an integrated manner. Modeling detail in this systems-level modeling tool is determined, to a significant extent, by findings from the models of individual phenomena and, especially, from the comparison of model predictions to results of separate experiments.

The Revised Source Term

On the basis of phenomenological and analytical severe accident research, the NRC has formulated a revised accident source term for use in reactor-related regulatory analyses. This revised source term, which is often called the “NUREG-1465 source term” or the “alternate source term (AST),” provides a more realistic description of radionuclide releases to the containment in a severe reactor accident. Distinct source terms are specified for both pressurized- and boiling-water reactors (PWRs and BWRs). Fission product releases to the containment are also specified in eight element categories that occur during the four phases of an accident (i.e., fuel cladding rupture, fuel degradation, core debris/concrete interactions, and late-phase revaporization processes).
Some important features of the source term are as follows:

- Releases to the containment are time-dependent.
- All radiologically important elements are considered.
- Iodine is specified to be released predominantly as metal iodide particles, but a fraction (5%) is also specified to be gaseous (HI, I$_2$, CH$_3$I, etc.).
- Both radionuclide deposition in the reactor coolant system and revaporization of the deposited materials have been considered in developing the description of releases to the containment.
- Rather small fractional releases of the refractory metal fission products (Ru, Mo, etc.) and the refractory oxide fission products (CeO$_2$, La$_2$O$_3$, etc.) are prescribed.

References


