Status of Safety and Environmental Activities in the US Fusion Program

David A. Petti[1], Susana Reyes[2], Lee C. Cadwallader[1], and Jeffery F. Latkowski[2]

[1]Idaho National Engineering and Environmental Laboratory,
Idaho Falls, ID, pti@inel.gov and lcc@inel.gov
[2]Lawrence Livermore National Laboratory, Livermore, CA,
reyes20@llnl.gov and latkowski1@llnl.gov

The safety and environmental (S&E) advantages of fusion have been recognized since the earliest days of the US fusion program. Over the past 25 years, the magnetic fusion energy (MFE) Fusion Safety Program at the Idaho National Engineering and Environmental Laboratory and the inertial fusion energy (IFE) safety group of the Fusion Energy Program at Lawrence Livermore National Laboratory have been conducting safety research and development (R&D) and S&E assessments of conceptual designs to demonstrate the S&E potential of fusion.

S&E research is focused on understanding the behavior of the largest sources of radioactive and hazardous materials in a fusion facility, understanding how energy sources in a fusion facility could mobilize those materials, developing integrated state of the art S&E computer codes and risk tools for safety assessment, and evaluating S&E issues associated with emerging design concepts in the fusion community. Some of the largest sources of hazards are chamber material reactions with air or steam, and chemical toxicity of fusion materials. A collaborative survey of the S&E characteristics - both radiological and chemical - of various IFE candidate target and coolant materials has been completed. Mobilization studies have addressed tungsten and Flibe mobilization, as well as other materials. Integrated state-of-the-art S&E analysis tools have been developed to address a variety of MFE and IFE safety issues, including magnet arcing, thermal hydraulic/source terms, tritium migration, and neutron transport and material activation, for accident analysis and radioactive waste assessment. Some of these tools have also supported Inertial Confinement Fusion and accelerator facilities, such as the National Ignition Facility and the Rare Isotope Accelerator, respectively. Waste management issues continue to be investigated and are receiving increased attention. Risk tools for safety assessment have produced a failure rate database, augmented a radiological dose code for fusion use, and developed sets of accident initiators for MFE and IFE. Our evaluations of S&E issues associated with emerging IFE design concepts include support to the High Average Power Laser (HAPL) program to advance the science and technology for a dry-wall, laser-driven IFE power plant, and collaboration with the Heavy Ion Fusion (HIF) and Z-Pinch programs for the development of alternative, thick-liquid-wall IFE concepts. Recent S&E support to MFE design concepts includes APEX and ARIES, and burning plasma experiment designs, including preliminary studies of the Fusion Ignition Research Experiment (FIRE) and detailed accident analyses for the International Thermonuclear Experimental Reactor (ITER).

Excellent progress has been made in understanding the nature of the S&E concerns associated with magnetic and inertial fusion. This paper presents key R&D highlights over the past 15 years, reviews recent safety assessment results for both MFE (e.g., APEX, ARIES, FIRE, ITER) and IFE (e.g., HYLIFE-II, SOMBRERO) designs, and discusses impact of the results on future programmatic directions in the fusion program.

This work was prepared for the US Department of Energy, Office of Fusion Energy Sciences, under the DOE Idaho Field Office contract number DE-AC07-99ID13727 and University of California Lawrence Livermore National Laboratory contract number W-7405-Eng-48.