BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO
SANTA BARBARA • SANTA CRUZ

COLLEGE OF ENGINEERING
DEPARTMENT OF NUCLEAR ENGINEERING
PER F. PETERSON
TELEPHONE: (510) 643-7749
FAX: (510) 643-9685
EMAIL: peterson@nuc.berkeley.edu

BERKELEY, CALIFORNIA 94720-1730

September 30, 2002

Dr. Farouk Eltawila
Director, Division of Systems Analysis and Regulatory
Effectiveness
Office of Nuclear Regulatory Research
Mail Stop T-10 E32
U.S. Nuclear Regulatory Commission,
Washington, DC 20555-0001

Re: Workshop on Key Issues Related to the Licensing of Future Non-Light Water Reactors--Discussion on Issue 6

Dear Dr. Eltawila,

Because I will not be able to attend the upcoming workshop, I wanted to provide input to the discussion on Issue 6, Containment vs. Confinement. The major questions under this issue relate to gas-cooled reactors, but it is valuable to place them in the context of reactors with water and other coolants.

Water-cooled reactors require a high-pressure, low-leakage containment to mitigate potential releases of radionuclides during severe accidents, because the process of long-term cooling of core material intrinsically creates a substantial mass flux of steam. Condensation of this steam, and eventual recycle back to the core, is required to control the containment pressure and to prevent the convective transport of radionuclides from the core to the external environment.

Because large uncertainty exists in the sequence of events that would cause substantial damage to a LWR core, the high-pressure containment function must be robust against damage and failures driven by a number of different potential energy release mechanisms, ranging from the initial blow down of the reactor to external events to long-term pressurization caused by hydrogen generation and/or core-concrete interactions. "Robustness" implies that any containment failure driven by these energy sources would be gradual and delayed, rather than catastrophic and timed with the peak source term aerosol inventories inside the containment. For example, the mechanisms for failure of containment integrity driven by overpressurization should be understood and should occur in a controlled way, as for example in the ESBWR where overpressurization of the primary containment is mitigated by controlled venting of gasses from the wet well into lower equipment rooms which have the same design pressure as the primary containment.

Reactors with low volatility coolants--liquid metals and molten salts--can employ low-pressure, low leakage containments, because their low-volatility coolants fundamentally limit

Attachment 8

the total quantity of gas or vapor that can be generated by coolant heating or chemical reactions. Thus the question of confinement, versus containment, is limited to gas-cooled reactors.

Gas-cooled reactors can be built with either high-pressure, low-leakage containments, or with low-pressure filtered confinements, where the filter system is designed to bypass during rapid gas release, as would occur with a large pipe break. The helium coolant in gas cooled reactors is inert and does not undergo phase change. Thus gas cooled reactors have smaller number of energy sources with potential to damage the mitigation function provided by a confinement and filter system, compared to the number of energy sources which could challenge an LWR containment. In particular, the stored energy of the compressed gas, and energy provided by external events, are the primary concerns, while energy generated by chemical reactions of coolant and fuel, and the phase change of water coolant, play a secondary role.

Clearly for gas-cooled reactors the most important function of either a containment or a confinement system is to protect vital equipment, particularly decay-heat removal equipment, from the effects of external events, and to prevent the types of gross structural failures that might permit large, sustained fluxes of air or steam to flow through the reactor core. A clear definition of design-basis external events, including sabotage, is important in designing the containment or confinement system to achieve this reliability of structural integrity. These aspects of the structural design clearly deserve careful regulatory scrutiny.

The containment or confinement of gas cooled reactors should also provide mitigation of any release that might occur due to core damage. The robustness of gas-cooled reactor fuel to damage at high temperatures, and the lack of a sustained convective flow from the core region into the containment, reduces the magnitude of the source term that must be considered relative to that expected under severe plant conditions in a light water reactor. For direct-cycle gas-cooled reactors, no chemical or thermal mechanisms exist to generate significant fuel damage while the reactor remains pressurized, because the cooling water supplied to a direct-power-cycle machine is at a substantially lower pressure than the helium coolant and thus can not leak in. Conversely, mechanisms can be postulated which could generate damage to fuel materials after protracted time periods following loss of coolant, due to air or steam ingress. At this time, safety analysis is likely to show the early venting of the primary coolant to equilibrate the confinement and external environment pressures, and the existence of a filter system in a low-flow-loss path between the confinement and the external environment, provides a more effective and robust mitigation of releases to the environment than would a high-pressure. low leakage containment, where substantial residual stored energy is retained inside the containment.

Sincerely yours,

Per F. Peterson
Professor and Chair
Department of Nuclear Engineering