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Alternative Passive Decay-Heat Systems for the Advanced High-Temperature Reactor

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File Name: DecayHeat06.Abstract
Manuscript Date: November 5, 2005
Abstract Due Date: November 15, 2005
Draft Paper Due Date: January 15, 2006
Final Paper Due Date: March 15, 2006
Abstract Length: 399 words (Limit: 400 words)

Session 3: Long-Term Reactor Programs and Strategies
2006 International Congress on the Advances in Nuclear Power Plants (ICAPP'06)
Embedded Topical in the 2006 American Nuclear Society Annual Meeting
American Nuclear Society
June 4–8, 2006
Reno, Nevada

*Oak Ridge National Laboratory, managed by UT-Battelle, LLC, for the U.S. Department of Energy under contract DE-AC05-00OR22725.

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The Advanced High-Temperature Reactor (AHTR) is a large [>2400 MW(t)] liquid-salt-cooled high-temperature reactor with the same safety goals and requirements as the modular very high temperature reactor (VHTR) with helium cooling and power outputs of ~600 MW(t). Within the U.S. Department of Energy Generation IV Program, the AHTR is being developed as an alternative-coolant VHTR. The AHTR uses the same graphite-matrix coated-particle fuel as helium-cooled VHTRs. Graphite has been demonstrated to be compatible with only two coolants: liquid fluoride salts and noble gases. In the AHTR, heat generated in the reactor core is transferred from the core with a clean liquid-fluoride salt to an intermediate heat exchanger. A secondary liquid salt then transfers the heat from the secondary heat exchanger to a Brayton power cycle for electricity production or to a thermochemical plant for hydrogen production.

As in the helium-cooled VHTR, the high negative Doppler coefficient ensures reactor shutdown if the core overheats. For decay-heat removal, three passive safety systems are being considered. This paper describes the three systems and evaluates their relative advantages and disadvantages. There are several major design considerations:

- *Material temperature limits*. Some designs of the AHTR have 950°C exit coolant temperatures.

- *Power level*. Economics improves with size, and commercial vendors have an interest in attaining power levels as high as 4000 MW(t).

- *Scalability*. This is the ability to scale the decay heat removal systems from small to large sizes.

The choice of decay heat system depends in part upon design goals. The three options are as follows.

- *Reactor Vessel Auxiliary Cooling System (RVACS)*. This is the same system used for the General Electric S-PRISM sodium-cooled fast reactor, where decay heat is removed through the reactor vessel to the environment. The primary difference is the higher operating temperature.

- *Direct Reactor Auxiliary Cooling System (DRACS)*. This system is similar to that used in the Experimental Breeder Reactor - II sodium-cooled fast reactor. Decay heat is removed with a natural circulation loop that transfers heat from the salt inside the reactor vessel to the environment.

- *Pool Reactor Auxiliary Cooling System (PRACS)*. In this system, the closed primary reactor system is located in a pool of cooler liquid salt. The pool is cooled by a DRACS-type system. This system has some of the characteristics of the Process Inherent Ultimate Safety pressurized-water concept that was partly developed by ABB-Atom in Sweden.