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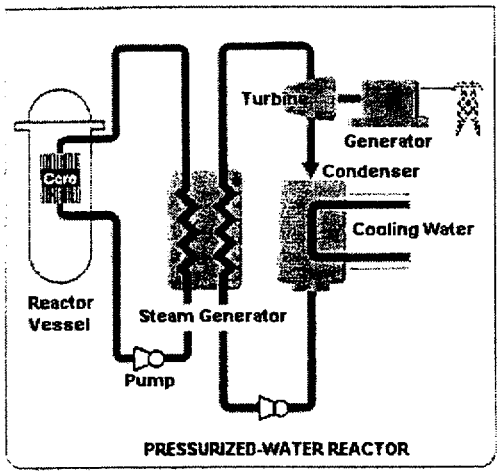
SAFETY PROBLEMS WITH PRESSURIZED WATER REACTORS IN THE UNITED STATES

BACKGROUND

Of the 110 operational nuclear power reactors in the United States, 73 of these reactors are pressurized water reactor (PWR) designs. Over half of these models are manufactured by Westinghouse with the remainder supplied by Combustion Engineering and Babcox & Wilcox. Each design uses the controlled atomic fissioning of enriched uranium fuel in the reactor pressure vessel to generate a tremendous amount of heat, to produce steam, which drives a turbine-generator system for electricity.

The fundamental characteristic of the PWR is that the primary coolant raises steam in a heat exchanger called a steam generator. Depending on the design, a reactor can have two to four steam generators; each steam generator consisting of a primary coolant loop comprised of thousands of steam generator tubes directly circulating water from the reactor under high pressure (approx. 2250 psi) and high temperature (600 F). The high pressure does not allow the water to boil in the primary coolant loop thus enabling more efficient heat transfer. In order to be effective heat exchangers the tubes are 3/4 inch in diameter with the tube wall being as thick as a dime. The heat is exchanged in the steam generator where water is allowed to turn to steam though a secondary loop that exits the reactor containment building to power the turbogenerator.



AGE-RELATED DEGRADATION OF PWR SYSTEMS AND COMPONENTS

As in any other industry, the nuclear industry is experiencing problems with the wear-and-tear of components and systems. Unlike other industries, however, the failure of safety related components at nuclear power plants can result in a catastrophic accident on a scale or larger than the radiological accident at Chernobyl. The industry is now plagued with age-related deterioration mechanisms unique to nuclear power operations. Chronic exposure to extreme radiation, heat, pressure, fatigue, and corrosive chemistry are combining to cause embrittlement of metal, cracking, and erosion of components integral to the protection of the public's health and safety. As nuclear reactors get older the chance of failure of this equipment only increases.

STEAM GENERATOR TUBE DETERIORATION

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Virtually all PWRs are experiencing accelerating deterioration of steam generator tubes because of the susceptibility of the metal used in this component and other safety-related parts. The Nuclear Regulatory Commission (NRC) reports that cracking of steam generator tubes is surging in US reactors. Cracking has been identified by NRC as having serious safety implications because the thousands steam generator tubes constitute a major reactor coolant pressure boundary. A multiple tube rupture in this system could result in a rapid loss of coolant accident in the reactor beyond the ability of the Emergency Core Cooling System to control. This could result in a meltdown of the reactor core. Because the steam generators are equipped with relief valves, a rupture of the primary coolant loop results in a radioactivity release that bypasses the containment structure with significant risk of a catastrophic accident.

The NRC has issued numerous warnings about steam generator deterioration. Commissioner Kenneth Rogers described this scenario as "a loaded gun, an accident waiting to happen." However, current NRC requirements for inspecting steam generator tubes are inadequate to detect unsafe conditions developing in nuclear power plants. The NRC admits that neither itself nor the industry are able to predict how fast cracks in tubes can grow, noting that in the duration of one 18-month operational cycle a reactor can experience a hundred-fold increase in cracked tubes.

The repair or replacement of steam generators is a great economic burden on the PWR operator, for the larger PWR units upwards of $300 million to replace. A number of PWRs licensed by the NRC for 40 years are beginning to see only ten effective power years before extensive repairs or replacement are required to keep them operational. In all cases, the deterioration of steam generators spells the increased potential for early closure of reactors in an increasing competitive electricity market and an increased risk of catastrophic radiological accident in the United States.

REACTOR PRESSURE VESSEL EMBRITTLEMENT

The reactor pressure vessel is by far the single largest safety-related component in the reactor. The pressure vessel is the principle boundary for the reactor core cooling capability and radiation containment system. A NRC report emphasizes the importance of this component stating "integrity of the reactor pressure vessel is essential in ensuring reactor safety." If the reactor pressure vessel fails, there is no backup system to cool the reactor and avoid an uncontrollable meltdown of the nuclear fuel.

Early in 1993, the NRC publicly identified 15 U.S. reactors where the pressure vessels had become so weakened by radiation as to call into question their continued operation. The agency said that the component was aging much faster than the manufacturers had anticipated. Caused by neutron bombardment from the reactor fuel core, "embrittlement " is the loss of ductility or the metal's ability to expand and contract to withstand stress under rapid cooling and pressurization. The initiation of the Emergency Core Cooling System could then place such stresses on an embrittled reactor vessel resulting in a phenomenon not unlike pouring cold water into a baked wine glass---resulting in the complete loss of integrity of the component.

This is known as Pressurized Thermal Shock or the severe overcooling of the reactor vessel. This event can cascade out of other accidents such as instrumentation failure, small-break loss of coolant accident or a steam generator tube rupture

Paul Gunter, NIRS, March, 1996