AN ILLUSTRATED TRANSLATION OF THE NRC'S REPORT ON "FAILURE OF SAFETY/RELIEF VALVE TEE-QUENCHER SUPPORT BOLTS" AT THE HATCH NUCLEAR PLANT

The Nuclear Regulatory Commission's (NRC's) Morning Report No. 2-2005-0005 dated March 14, 2005, related the following information received from the owner of the Edwin I. Hatch nuclear plant in Georgia:

> *While shutdown for a refueling outage, the licensee conducted a routine visual inspection of the Unit 2 torus and found five broken bolts associated with the safety/relief valve Tee-Quencher supports. One bolt on five different Tee-Quencher support plates had failed. The Tee-Quenchers are attached to the end of the safety/relief valve discharge piping below the torus water level and consist of "T" shaped piping with steam spargers attached at each end. The Tee-Quenchers are used to eliminate unbalanced forces on the piping and distribute the hydrodynamic loads on the torus during safety/relief valve operation. Failure of the bolts could impact the integrity of the safety/relief valve discharge piping. There are eleven Tee-Quenchers, each secured by 4 bolts. The licensee has replaced all 44 bolts in the Unit 2 torus.*
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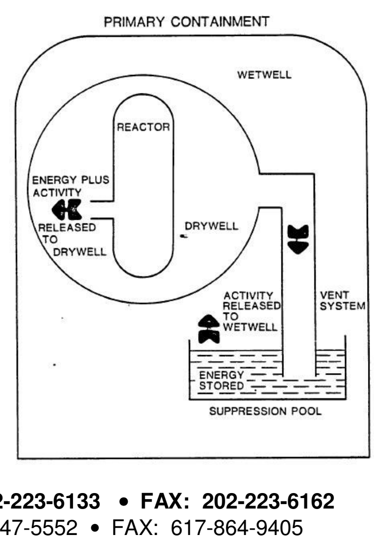
> *The bolts are high-strength alloy steel (ASTM A540 Grade B21) and torqued to about 70% of yield strength. These bolts were installed in both the Unit 1 and Unit 2 torus during modifications in the early 1980's. A failure analysis performed by a testing facility has determined that the bolt failures were most likely caused by stress corrosion cracking and possibly hydrogen embrittlement. The potential for hydrogen embrittlement was attributed to conditions in the torus which include a zinc primer coating. Based on engineering calculations, the licensee has determined that three intact bolts on a Tee-Quencher support plate are sufficient to withstand the loading from safety/relief valve operation. The licensee is also evaluating postulated conditions of only two intact bolts per Tee-quencher and has preliminarily determined that this would also be sufficient to withstand the forces of safety/relief valve operations.*

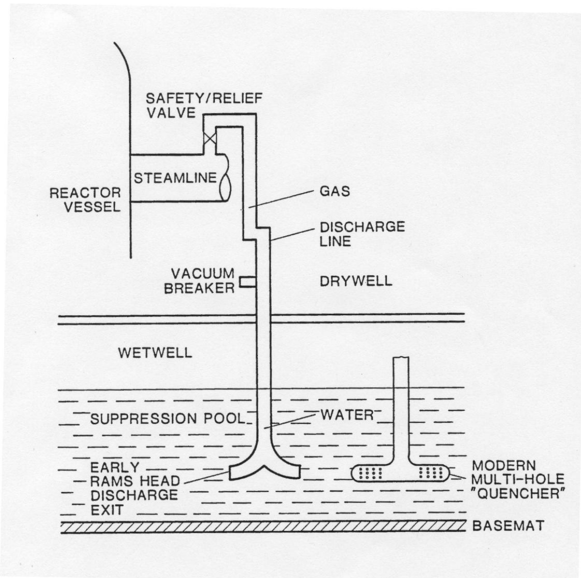
This NRC report demonstrates that stringing together a bunch of English words doesn't guarantee a readable passage any more than stringing together a bunch of numbers guarantees a winning lottery ticket combination. This issue brief translates this NRC report into more commonly used English aided by illustrations.



The Hatch nuclear plant features two boiling water reactors (BWRs). In the BWR design, the reactor containing the nuclear fuel is surrounded by a structure called the primary containment. The primary containment is a principal barrier intended to protect the public from lethal radioactivity released from damaged fuel during an accident.

The primary containment is made of reinforced concrete to provide strength against the energy released from the reactor during an accident. That energy can be high enough to burst the thick, reinforced concrete walls if it wasn't for energy absorption by nearly two million gallons of water sitting in the suppression pool (also called the torus at Hatch due to its doughnut shape). During an accident, the energy is channeled through vent pipes and discharged below the surface of the water in the suppression pool. The water absorbs much of that energy, enabling the reinforced concrete walls to withstand the remaining energy.

The suppression pool also receives energy discharged from the piping that carries steam from the reactor vessel to the turbine. During accidents, valves in those steam pipes close within five seconds to end the flow of potentially radioactively contaminated steam to the environment. The rapid close of these valves could over-pressure the pipes and cause them to break if it wasn't for safety/relief valves that open to let the steam flow into the suppression pool as shown in the graphic.



The original design discharged the steam beneath the surface of the suppression pool water via what were called rams head nozzles. Experience revealed problems with this arrangement, particularly when only one or two of the eleven safety/relief valves opened. Steam blowing unequally into the suppression pool water caused "sloshing." The wave action from two million gallons of water could damage the suppression pool's walls. To prevent such damage, the rams head nozzles were replaced with tee-quenchers. Like a garden sprinkler hose having many spray holes, the tee-quenchers disperse the steam flow into the water so as to minimize wave action.

At Hatch, each of the eleven tee-quenchers on Unit 2 is bolted to support plates mounted on the basemat of the suppression pool using four bolts. Workers at Hatch discovered one broken bolt on five of the eleven tee-quenchers. The bolts broke due to a combination of stress and corrosion. Impurities in the suppression pool water caused pitting of the metal bolts that forces acting on the bolts turned into cracking that grew until bolts failed. It is also possible that hydrogen present in the suppression pool from an epoxy liner embrittled the metal bolts, allowing their cracks to grow faster and hastening their ultimate failure.

Workers replaced all 44 bolts on the tee-quenchers on Hatch Unit 2 – the five broken bolts plus the 39 other bolts. Similar to showing that a wheel can stay on a car with one lug nut missing, Hatch's owner performed an analysis reportedly showing that three non-broken bolts were sufficient to kept the tee-quenchers in place when the safety/relief valves opened and let steam flow into the suppression pool.

The broken bolts were found during a routine visual inspection. The goal of these inspections is to identify cracked bolts and replace them before they break and reduce safety margins. That didn't happen in this case and the plant's owner and the NRC should seriously evaluate whether the scope and frequency of these inspections needs to be increased to prevent future surprises. Visual inspections may not be sufficient to find degradation like stress corrosion cracking in time to prevent failures.

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