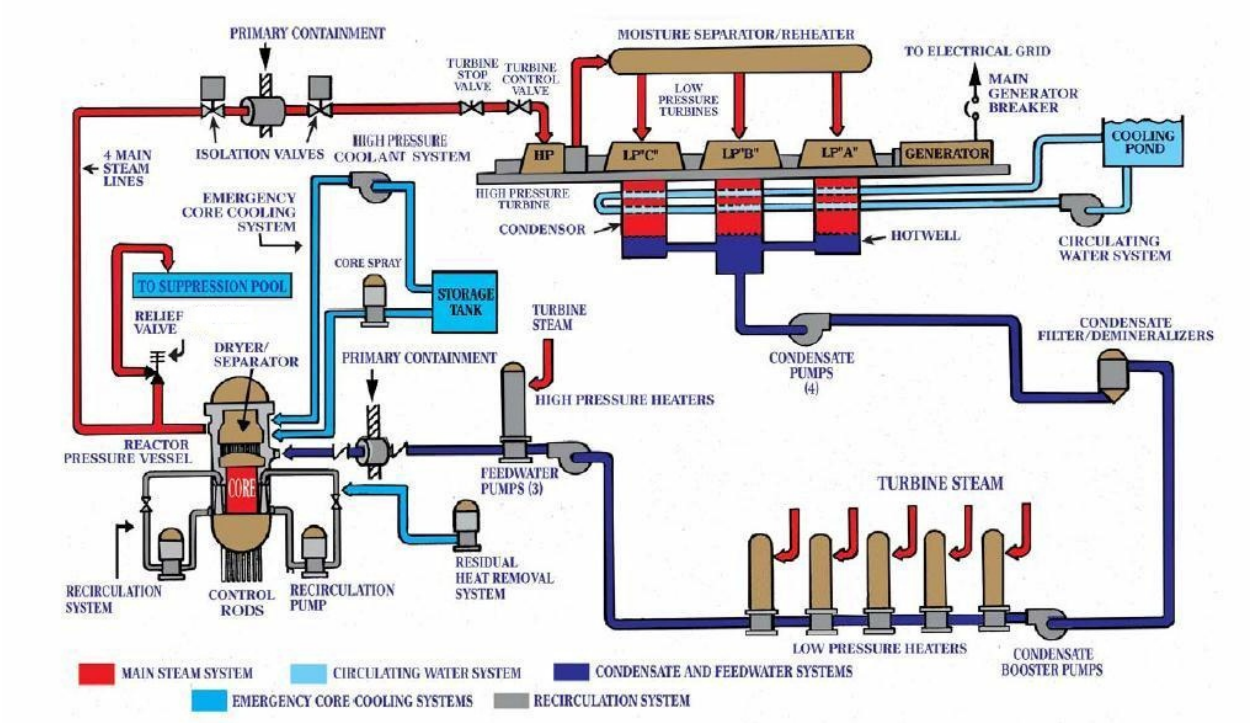
No Relief for Vermont Yankee

On December 22, 2010, Vermont Yankee's owner informed the Nuclear Regulatory Commission that workers had determined during the recent refueling outage that two of the four main steam safety relief valves had problems likely rendering them inoperable during the prior operating cycle.



Vermont Yankee has four relief valves (represented by a single Relief Valve on the left center of the figure) mounted on the piping carrying steam from the reactor vessel to the main turbine. These relief valves are normally closed, but can open to control pressure by discharging steam to the water-filled suppression pool inside containment.

The relief valves are designed to automatically open when pressure inside the steam piping rises about 10 percent above its normal pressure. Such pressure increases occur, for example, when one of the downstream isolation valves closes or the main turbine trips, causing the turbine stop valves to close in fractions of a second. These valve closures terminate the flow of steam to the main turbine and trigger the automatic shut down of the reactor. The relief valves open to provide a pathway for the steam – thereby controlling pressure – until the reactor's shut down curtails steam production.

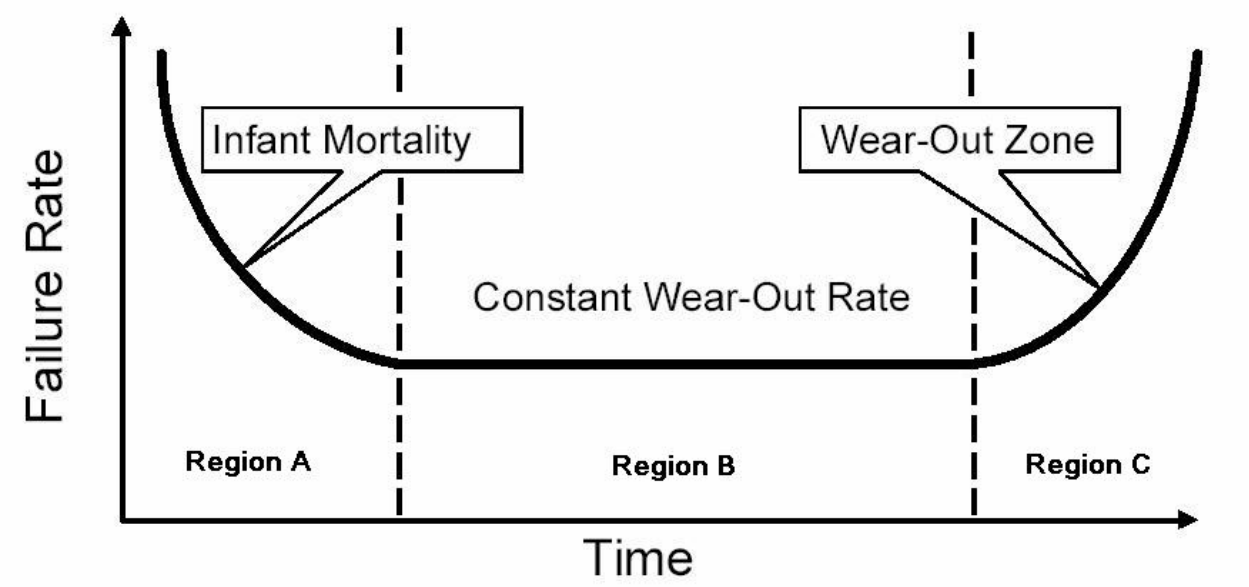
The relief valves are also designed to automatically open when needed to assure adequate cooling of the reactor core. If an accident results in a small loss of cooling water from the water vessel, as happened at the Three Mile Island Unit 2 reactor in March 1979, Vermont Yankee has a single emergency system (called the High Pressure Coolant System in the figure) to replace the lost water inventory. If that system fails for any reason, the design calls for the relief valves to automatically open. Steam flowing through the open relief valves to the suppression pool lowers the pressure inside the reactor vessel until one or more from an array of backup systems (labeled the Residual Heat Removal and Core Spray systems in the figure) can supply makeup water. For these systems to work, the pressure inside the reactor vessel must drop to less than half its normal pressure.

During the past operating cycle, Vermont Yankee did not experience an event that required the relief valves to control pressure. The problems identified by workers during last fall's refueling outage had to be reported to the NRC because the potential existed for the plant's response to such events, had one occurred, to be less than needed to protect the public.

Had an isolation valve closed or the main turbine tripped from full power, the failure of two relief valves to open properly could have caused pressure in the reactor vessel and steam piping to rise above design limits. The piping could have ruptured due to overpressure or parts inside the reactor vessel could have been damaged.

Had a loss of coolant accident (LOCA) occurred with the failure of the high pressure coolant system, the failure of two relief valves to open properly could have caused damage to the nuclear fuel in the reactor core due to overheating. The relief valves failing to open could have lengthened the time needed to lower the pressure inside the reactor vessel down to the level where the residual heat removal and/or core spray systems supplied adequate cooling water.

The relief valve problems were attributed to leakage past thread seals in the valves. While Vermont Yankee has been operating for decades, the thread seals had been replaced during the previous refueling outage in 2008. The replacement parts had only been installed for a single operating cycle and failed at some point during that cycle. Such failures are not unexpected. They can be explained by the so-called "bathtub curve" showing the chance of failure as a function of time.



The relief valve thread seals had been replaced during the 2008 refueling outage because they were heading towards, if not already in, the wear-out zone where chance of failure increases. But the replacement parts are subject to a comparably high failure rate due to factors like infant mortality.

An aging nuclear plant like Vermont Yankee poses challenges to safety. Many of its parts are in the wear-out zone or soon will be there. Replacing the aging parts with brand new parts merely swaps to the other high-risk end of the bathtub curve. The benefit derived from swapping the risk is that the replacement parts, if they successfully avoid infant mortality, experience a region of reduced risk for awhile before wearing out.

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