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NPRE 449
September 4, 2024

1. (Read T-K chapter 1, NPC PWR, and NRC BWR handouts on box) Compare the PWR and BWR in terms of their basic features, characteristics of their thermodynamic cycle, and characteristics of their fuel.

Both the PWR and BWR operate in the thermal neutron spectrum, have H_2O as the moderator and coolant, and have ~3% enriched UO_2 as the fuel.

BWR is a single-coolant system because it produces steam in the primary loop, which means irradiated steam passes over the turbine.

PWR is a two-coolant system because there is no steam produced in the primary loop and the steam is produced in a steam generator, which is the interface between the primary and secondary loop.

Both the PWR and BWR use fuel rods, have small fuel-to-water volume ratios, and rather large fuel rod centerline-to-centerline spacing or rod pitch. The low packing fraction allows the use of simple square arrays. The fuel assembly uses spacer grids, which contact and support each fuel rod.

BWRs and PWRs generally differ in the number of fuel rods in each assembly with PWRs generally having more rods per assembly than BWRs. Modern BWRs typically have 64 (8x8, 2^6) fuel rods per assembly, whereas PWRs typically have 225 (15x15) to 289 (17x17) rods per assembly.

2. Explain how decay heat is removed from a PWR, citing specific system(s) and how those system(s) operate.

There are two systems that allow decay heat to be removed from a PWR: the auxiliary feedwater system with the steam dump system (turbine bypass valves) and the residual heat removal system.

The first system is used when the decay heat is enough to evaporate sufficient quantities of water to remove heat via the steam generator. The auxiliary feedwater system pumps water from a storage tank to the steam generators, which is then boiled to make steam. This steam can be sent through the steam dump valves into the main condenser where it is condensed into water. This water is circulated, which condenses more steam and transfers the heat to the environment. However, if the steam dump system is not available, the steam can be dumped to the atmosphere via the atmospheric relief valves.

The residual heat removal system is used once the decay heat is no longer enough to remove heat via the steam generator. With the residual heat removal system, some reactor coolant is routed through a heat exchanger, which is cooled by the component cooling water system, which is transferred to the service water system, which is then dumped to the environment.

3. What are the two purposes of the PWR ECCS? What system(s) within the ECCS is/are still available without electrical power? Explain how the system(s) work.

The two purposes of the ECCS are to provide core cooling to minimize fuel damage following a LOCA and provide extra neutron poisons to ensure the reactor remains shutdown following the cooldown.

The system that does not require electrical power is the cold leg accumulator. The cold leg accumulators do not need power because they are simply tanks of borated water pressurized with nitrogen gas, so that whenever the pressure drops enough, the borated water is automatically injected into the reactor coolant system.

4. Explain how decay heat is removed from a BWR, citing specific system(s) and how those system(s) operate.

Decay heat is removed by bypassing the turbine and dumping steam directly to the condenser. Once the decay heat is low enough to pressurize the loops to lower than 50 psig, water is pumped from the reactor recirculation loop, through a heat exchanger, and back to the reactor via the recirculation loop.

When bypassing the turbine, the steam is too energetic to go directly to the heat exchanger, so the excess energy is removed by the condenser before the steam has low enough energy to where the heat exchanger can be used. Once the heat exchanger is in use (below an internal pressure of 50 psig), the heat is removed from the steam with service water and the now condensed steam is sent back into the core via the recirculation pump.

5. What systems make up the BWR ECCS? What system(s) within the ECCS is/are still available without electrical power? Explain how the system(s) work.

There are two high pressure systems and two low pressure systems. The high pressure systems are the high pressure coolant injection system and the automatic depressurization system. The low pressure systems are the low pressure coolant injection mode of the residual heat removal system and the core spray system.

The high pressure coolant injection system does not require auxiliary ac power. The HPCI system takes water from a condensate storage tank and pumps it using the turbine. This condensate goes into the main feedwater, which goes into the reactor vessel.