General Electric Advanced Technology Manual

Chapter 6.0

BWR Differences

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6.0 BWR DIFFERENCES

The BWR Differences chapter is provided to give the student some insight into the major differences between the various BWR product lines. Table 6.0-1 has been developed to allow comparisons of various BWR functions for the product lines BWR/2 through BWR/6. The figures in this chapter illustrate most of the more important differences indicated in the tables.

6.0.1 Emergency Core Cooling Systems and RCIC

The ECCS package provided for a particular product line is dependent primarily on the vintage of the plant. All BWR product lines have high pressure and low pressure ECCSs. The BWR/2 product line high pressure ECCS consists of the isolation condenser system and the automatic depressurization system. Low pressure ECCS consists of a core spray system.

The BWR/3 product line high pressure ECCS pumping system consists of either a feedwater coolant injection system or a high pressure coolant injection system. The BWR/3 low pressure ECCS consists of two core spray loops and two low pressure coolant injection loops - either as a separate system or as part of the residual heat removal system.

The BWR/4 product line ECCS high pressure pumping consists of a high pressure coolant injection system that delivers its flow to the vessel annulus. The low pressure ECCSs consists of two core spray system loops and two or four LPCI loops.

The BWR/5 and BWR/6 product lines have the same ECCS package. The ECCS high pressure pumping system consists of a high pressure core spray system. The low pressure ECCSs consists of one low pressure core spray system loop and three LPCI loops. The LPCS system is similar to a single core spray loop of the earlier BWR/4 product line. The three LPCI loops deliver low pressure flooding water directly inside the core shroud.

In the event the reactor becomes isolated from its heat sink some component or system must control reactor vessel pressure and inventory. All BWR plants have safety relief valves (SRVs) to provide over pressure protection, and hence control reactor pressure. Some BWR facilities have systems which can control pressure without requiring the use of the SRVs. All BWR facilities have a means of providing high pressure makeup water to the reactor vessel to compensate for inventory loss via the pressure control method.

In the case of the BWR/2 product line and certain plants of the BWR/3 product line, both of the isolation functions are carried out by a single system called the isolation condenser System. The isolation condenser system draws off reactor steam, condenses the steam in a condenser, and returns the resultant condensate to a recirculation system suction line. By conserving inventory, this system eliminates the need for additional sources of high pressure makeup.

All BWRs of other product lines use SRVs for pressure control and the reactor core isolation cooling system to provide high pressure makeup water to the reactor vessel. Additionally, all BWR/3 & 4 product line plants have a high pressure coolant injection system (HPCI), while all BWR/5, and all BWR/6 product line plants utilize high pressure core spray (HPCS) for additional makeup.

6.0.2 Primary Containments

There are three containment packages used in the various BWR product lines. All BWR/2, BWR/3, and early model BWR/4 product line plants have the Mark I Containment. Later model BWR/4 and all BWR/5 product line plants have the Mark II Containment. All BWR/6 product line plants have the Mark III Containment. All three containments have the pressure suppression feature.

The Mark I Containment consists of a drywell (in the shape of an inverted light bulb), a suppression chamber (in the shape of a toroid), and a network of vents which extend radially outward and downward from the drywell to the suppression chamber. The drywell and suppression chamber have the same design pressure.

The Mark II Containment is sometimes referred to as an over-under containment. It consists of a drywell (in the shape of a truncated cone) a suppression chamber directly below the drywell (in the shape of a right circular cylinder), and a network of vertical vents extending downward from the drywell to the suppression chamber. The drywell and suppression chamber have the same design pressure.

The Mark III Containment employs the construction simplicity of a dry containment while retaining the advantage of a pressure suppression type containment. The Mark III Containment consists of a drywell (shaped like a right circular cylinder), a suppression pool (most of which is outside but some of which is inside the drywell), a weir wall (that bounds the suppression pool on the inside of the drywell), and the containment vessel which is cylindrical with a domed head, completely surrounds the drywell and suppression pool, and is both a pressure boundary and a fission product boundary.

In the Mark I and Mark II Containment designs, short term control of post LOCA hydrogen gas concentration is accomplished by inerting the primary containment with nitrogen gas for normal plant operation. The nitrogen gas is used to displace the oxygen in the air and to prevent an explosive mixture of hydrogen and oxygen from forming. Long term control of post LOCA hydrogen gas concentration is accomplished by adding additional nitrogen gas and then venting the primary containment to the standby gas treatment system. There are also hydrogen recombiners present in the BWR/5 design. They recombine hydrogen gas and oxygen gas into water vapor.

In the Mark III Containment design, short term control of post LOCA hydrogen gas is first

achieved because of the tremendously larger volume of the containment vessel (as compared to the Mark I or Mark II designs). When drywell hydrogen gas concentration starts to approach the flammability limit, drywell mixing compressors are started. They purge the hydrogen gas from the drywell into the containment. Long term control of post LOCA hydrogen gas concentration is accomplished by hydrogen igniters, which are distributed glow plugs similar to the ones used in PWR ice condenser containments.

Table 6.5-1 presents a comparison of the three BWR containment types with regard to the same or similar parameters.

Table 6.0-1 BWR Differences

Function	BWR/2	BWR/3	BWR/4	BWR/5	BWR/6
Forced Circulation	5 recirc loops; no jet pumps	2 recirculation loops; 20 jet pumps	2 recirculation loops; 20 jet pumps	2 recirculation loops; 20 jet pumps	2 recirculation loops; 20 or 24 jet pumps
Internal Pump Design	NONE	Single nozzle jet pump	Single nozzle jet pump	Five nozzle jet pump	Five nozzle jet pump
Flow Control Method	Variable Speed Pumps	Variable Speed Pumps	Variable Speed Pumps	2 speed pumps and FCV	2 speed pumps and FCV
Reactor Isolation Pressure Control	Isolation Condenser and SRVs	Isolation Condenser and SRVs	All use SRVs	All use SRVs	All use SRVs
Reactor Isolation Inventory Control	Isolation Condenser	Isolation Condenser	RCIC	RCIC	RCIC
Shutdown Cooling	Shutdown Cooling System	Shutdown Cooling system or MODE of RHR system	Shutdown Cooling MODE of RHR system	Shutdown Cooling MODE of RHR system	Shutdown Cooling MODE of RHR system
Containment Spray and Cooling	Containment Spray System	MODE of LPCI or RHR System	MODE of RHR system	MODE of RHR system	MODE of RHR system
ECCS High Pressure Pumping	Feedwater Pumps	HPCI	HPCI	HPCS	HPCS
ECCS High Pressure Pumping Delivery Point	Vessel annulus via feedwater sparger	Vessel annulus via feedwater sparger	Vessel annulus via feedwater sparger	Directly above core outlet (one spray ring)	Directly above core outlet (one spray ring)
ECCS High Pressure Pump Type	Normal RFPs with and without emergency power	Normal RFPs or Turbine Driven HPCI	Turbine Driven	Motor Driven	Motor Driven

Table 6.0-1 BWR Differences (continued)

Function	BWR/2	BWR/3	BWR/4	BWR/5	BWR/6
ECCS Blowdown	ADS	ADS	ADS	ADS	ADS
ECCS Low Pressure Spray	Two core spray (independent) loops	Two core spray (independent) loops	Two core spray (independent) loops	One LPCS loop	One LPCS loop
ECCS Low Pressure Flooding	NONE	LPCI sys, 2 loops; or LPCI MODE of RHR	LPCI MODE of RHR, 2 independent loops (2 plants have 4 loops)	LPCI MODE of RHR, 3 independent loops	LPCI MODE of RHR, 3 independent loops
ECCS Low Pressure Flooding Deliver point		Recirculation pump discharge pipe	Recirculation pump discharge pipe or inside shroud (core region)	Inside core shroud, core region	Inside core shroud, core region
Standby Coolant Supply	UHS to condenser and then feedwater	From UHS to Feedwater or RHR	From UHS to RHR	From UHS to RHR	From UHS to RHR
Containment Package	Mark I	Mark I	Mark I or II	Mark II	Mark III
Primary Containment Fission Product Barrier	Drywell and Suppression Pool	Drywell and Suppression Pool	Drywell and Suppression Pool	Drywell and Suppression Pool	Containment
Hydrogen Control Short Term	Nitrogen inerting during normal	Nitrogen inerting during normal	Nitrogen inerting during normal	Nitrogen inerting during normal	Larger volume; mixing compressors
Hydrogen Control Long Terms	Nitrogen inerting; venting to SGTS	Nitrogen inerting; venting to SGTS	Nitrogen inerting; venting to SGTS; recombiners	Nitrogen inerting; venting to SGTS; Recombiners	Hydrogen recombiners; hydrogen igniters
Rod Control	RMCS; one rod at a time; standard relays and timer	RMCS; one rod at a time; standard relays and timer	RMCS; one rod at a time; standard relays and timer or solid state	RMCS; one rod at a time; solid state	RC&IS; up to four rods at a time; Solid state