NUCL 40200 Engineering of Nuclear Power Systems

Assignment 2

(a) Using two tables below one on BWR-ABWR and another on AP1000-AP600- PWR prepare two comparative tables on the difference between the thermalhydraulics design characteristics between BWR and ABWR and between PWR, AP600 and AP1000. Comment on these comparative tables
(b) List improvements on the advanced reactors and the GEN IV reactors compared to the current LWR reactors. List all system, safety and security improvements

Table 4.4-1 Typical Thermal–Hydraulic Design Characteristics of the Reactor Core

General Operating Conditions**	BWR/6 238-748	ABWR*
Reference design thermal output (MWt)	3579	3926
Power level for engineered safety features (MWt)	3730	4005
Steam flow rate, at 420°F final feedwater temperature (Mlb/hr)	15.40	16.84
Core coolant flow rate (Mlb/hr)	104.0	115.1
Feedwater flow rate (Mlb/hr)	15.367	16.807
System pressure, nominal in steam dome (psia)	1040	1040
System pressure, nominal core design (psia)	1055	1055
Coolant saturation temperature at core design pressure (°F)	551	551
Average power density (kW/L)	54.1	50.6
Core total heat transfer area (ft^2)	73,303	83,176
Design operating minimum critical power ratio (MCPR)	See Table 15.0-1	
Core inlet enthalpy at 420°F FFWT (Btu/lb)	527.7	527.6
Core inlet temperature at 420°F FFWT (°F)	533	533
Core maximum exit voids within assemblies (%)	79.0	75.1
Core average void fraction, active coolant	0.414	0.408
Active coolant flow area per assembly ($in.^2$)	15.164	15.678
Core average inlet velocity (ft/sec)	6.98	6.43
Maximum inlet velocity (ft/sec)	8.54	7.45
Total core pressure drop (psi)	26.4	24.4
Core support plate pressure drop (psi)	22.0	20.0
Average orifice pressure drop, central region (psi)	5.71	8.75
Average orifice pressure drop, peripheral region (psi)	18.68	17.69
Maximum channel pressure loading (psi)	15.40	10.9
Average-power assembly channel pressure loading (bottom) (psi)	14.1	9.5
Shroud support ring and lower shroud pressure loading	25.7	23.9
Upper shroud pressure loading (psi)	3.7	3.5

Table of standard PWR-AP1000 Thermalhydraulics Characteristics

---

Parameters	AP1000	AP600	PWR
Reactor core heat output (MWt)	3400	1933	3800
Reactor core heat output (10^6 Btu/hr)	11,601	6596	12,969
Heat generated in fuel (%)	97.4	97.4	97.4
System pressure, nominal (psia)	2250	2250	2250
System pressure, minimum steady-state (psia)	2190	2200	2204
Coolant Flow[5]			
Total vessel thermal design flow rate (10^6 lbm/hr)	113.5	72.9	145.0
Effective flow rate for heat transfer (10^6 lbm/hr)	106.8	66.3	132.7
Effective flow area for heat transfer (ft^2)	41.5	38.5	51.1
Average velocity along fuel rods (ft/s)	15.9	10.6	16.6
Average mass velocity (10^6 lbm/hr-ft^2)	2.41	1.72	2.60
Coolant Temperature[6][8]			
Nominal inlet (°F)	535.0	532.8	561.2
Average rise in vessel (°F)	77.2	69.6	63.6
Average rise in core (°F)	81.4	75.8	68.7
Average in core (°F)	578.1	572.6	597.8
Average in vessel (°F)	573.6	567.6	593.0
Heat Transfer			
Active heat transfer surface area (ft^2)	56,700	44,884	69,700
Avg. heat flux (BTU/hr-ft^2)	199,300	143,000	181,200
Maximum heat flux for normal operation (BTU/hr-ft^2)[7]	518,200	372,226	489,200
Average linear power (kW/ft)[8]	5.72	4.11	5.20
Peak linear power for normal operation (kW/ft)[7][9]	14.9	10.7	14.0
Peak linear power (kW/ft)[7][11] (Resulting from overpower transients/operator errors, assuming a maximum overpower of 118%)	≤22.45	22.5	≤22.45
Heat flux hot channel factor (F_Q)	2.60	2.60	2.70
Peak fuel center line temperature (°F) (For prevention of center-line melt)	4700	4700	4700
Fuel assembly design	17x17 XL Robust Fuel	17x17	17x17 XL Robust Fuel/ No IFM
Number of fuel assemblies	157	145	193
Uranium dioxide rods per assembly	264	264	264
Rod pitch (in.)	0.496	0.496	0.496
Overall dimensions (in.)	8.426 x 8.426	8.426 x 8.426	8.426 x 8.426
Fuel weight, as uranium dioxide (lb)	211,588	167,360	261,000
Clad weight (lb)	43,105	35,555	63,200
Number of grids per assembly Top and bottom - (Ni-Cr-Fe Alloy 718) Intermediate Intermediate flow mixing	 2[13] 8 ZIRLO™ 4 ZIRLO™	 2[12] 7 Zircaloy-4 or 7 ZIRLO™ 4 Zircaloy-4 or 5 ZIRLO™	 2 8 ZIRLO™ 0
Loading technique, first cycle	3 region nonuniform	3 region nonuniform	3 region nonuniform
Fuel Rods			
Number	41,448	38,280	50,952
Outside diameter (in.)	0.374	0.374	0.374
Diametral gap (non-IFBA) (in.)	0.0065	0.0065	0.0065
Clad thickness (in.)	0.0225	0.0225	0.0225
Clad material	ZIRLO™	Zircaloy-4 or ZIRLO™	Zircaloy-4/ ZIRLO™
Fuel Pellets			
Material	UO_2 sintered	UO_2 sintered	UO_2 sintered
Density (% of theoretical)	95.5	95	95
Diameter (in.)	0.3225	0.3225	0.3225
Length (in.)	0.387	0.387	0.387