

NUCL 40200 Engineering of Nuclear Power Systems

Assignment 1

Attached are 9 tables on the reactor design, various components geometry and thermal characteristics for PWR, BWR and HTGR. The tables are taken from a book: James Rust, Nuclear Power Plant Engineering, Haralson Publishing Co. 1979.

(a) Read each table and prepare your own tables for each that have two columns one in SI (MKS) units and other in British units. Please submit your work on electronic file (either excel files or MS word) and a hard copy.

(b) Prepare a comparative table for the following on PWR, BWR, HTGR, CANDU reactors. Include with approximate size and dimensions if you have.

- (1) The containment components –include all you have studied
- (2) Reactor core – include fuel type, control rods and other components
- (3) Any auxiliary systems of the reactor – such as refueling systems and others

Table 1.1

Design Parameters for PWR Reactor Vessel

Base Material	Low - Alloy Steel
Cladding Material	Stainless Steel and Inconel (zircaloy)
Design Pressure	2499.999971 psi
Design Temperature	669.2 F
Operating Pressure	2249.999872 psi
Hydrostatic Test Pressure	31255.00003 psi
O.D. Including Nozzles	275 in
I.D.	182 in
Overall Height	516 in
Vessel Wall Thickness	9.125 in
Inlet Nozzle, I.D.	30.35905512 in
Outlet Nozzle, I.D.	38 in
Core Flood Nozzle, I.D.	2.765 in
Water Volume	35384.19643 gallon US

Table 1.2**PWR core geometry and thermal hydraulic characteristics**

Thermal Output	12966138213	Btu/hr
Equivalent	12384914.01	Btu/hr
Height/Diameter	1.05	
Active Core Volume	2441663.998	in ³
Average Core Power Density	5311727.724	Btu/hr/in ³
Fuel Weight	22707.61301	lb
Specific Power	57110920.07	Btu/hr/lbU
Burnup	1225795357	Btu/lbU
Conversion Ratio	0.5	
Number of Fuel Assemblies	241	
Fuel Element Array	16x16	
Assembly Dimensions	8x8	in, in
Assembly Pitch	8.15	in
Number of Fuel Rods/Assembly	236	
Total Number of Fuel Rods	56876	
Fuel Element Pitch	0.504	in
Fuel Element O.D.	0.382	in
Pitch/Diameter	1.33	
Clad Thickness	0.025	in
Fuel Pellet Diameter	0.325	in
Pellet-Clad Gap	0.0035	in
Fuel Enrichment	1.9/2.4/2.9	
System Pressure	2250.000003	psi
Coolant Flow	44166.74822	lb/s
Average Linear Heat Rate	1529.95696	Btu/hr/in ³
Maximum Linear Heat Rate	2294.93544	Btu/hr/in ³
Average Heat Flux	205999.4928	Btu/hr ft ²
Maximum Heat Flux	1502567.679	Btu/hr ft ²
Minimum DNBR	1.3	
Inlet Temperature	564.98	F
Outlet Temperature	622.4	F
Maximum Fuel Temperature	2341.94	F

Table 1.3**PWR pressurizer design parameters**

Overall Height	633	in
Overall Diameter	92.9133858	in
Normal Operating Water Volume	1203.93701	in
Normal Operating Steam Volume	802.677165	in
Design Temperature	649.9994	F
Operating Temperature	618.49994	F
Design Pressure	2500	psi
Operating Pressure	2335.00001	psi
Installed Heater Power	3412.14164	Btu/hr
Number of Safety Valves	6	
Safety Valve Size	3	in
Number of Relief Valves	2	
Relief Valve Size	2.5	in
Spray Rate		
Maximum	13.3338494	gallon/s
Continuous	0.01666725	gallon/s
Shell Material	Mn-Mo	
Cladding	Stainless Steel	
Dry Weight	235000	lb
Flooded Weight	347320	lb

Table 1.4**Vertical U-tube steam generator design data**

Dry Weight	1428900	lb
Flooded Weight	2220000	lb
Normal Operating Weight	1725000	lb
Overall Height	816	in
Upper Shell, O.D.	266.4	in
Lower Shell, O.D.	189.6	in
Primary Side		
Design Pressure	2500	
Design Temperature	813.7994	F
Operating Pressure	2250	F
Inlet/Outlet Temperature	621/564.5	F, F
Secondary Side		
Design Pressure	1270	
Design Temperature	5458.388	F
Feedwater Inlet Temperature	449.996	F
Steam Outlet Pressure	1070	psi
Steam Outlet Temperature	552.8998	F
Stream Quality	99.75	
Steam Flow (per Generator)	2499.711	lb/s

Table 1.5**Once-through steam generator design data**

Dry weight	1080000.001	lb
Overall Height	906	in
Shell I.D.	139.884252	in
Number of Tubes	16000	
Tube Size, O.D.	0.625/0.0374	in, in
Effective Tube Length	624	in
Steam Flow per Steam Generator	2154.723193	lb/s
Steam Temperature, SH	601.44/50	F
Steam Pressure	1060.000002	psi
Feedwater Temperature	464.99	F
Primary Flow per Steam Generator	1.320329292	psi
Primary Temperature (inlet/outlet)	625/569	F
Heat Transferred per Steam Generator	1.72E+06	Btu/s

Table 1.6**Design Parameters for BWR reactor vessel**

Base Material	Low Alloy Steel
Cladding Material	Stainless Steel
Design Pressure	1250.000003 psi
Design Temperature	574.988 F
Operating Pressure	1040.000001 psi
I.D.	238 in
Wall Thickness, min/max	5.7/6.46 in, in
Height	852 in
Number Recirculation Loops	2
Number of Jet Pumps	20
Recirculation Line Pipe Sizes, I.D.	24 in
Recirculation Pump Flow	5900.215539 gallon/s
Number of Steam Separators	263
Steam Separator Pressure Drop	7.300000008 psi
Flow per Separator	110.833434 lb/s
Vessel Exit Steam Quality	99.6
Vessel Weight	19500015.23 lb

Table 1.7**BWR core geometry and thermal-hydraulic characteristics**

Thermal Output		
Active Height	148	in
Equivalent Active Diameter	144	in
Height/Diameter	1.03	
Active Core Volume	3905280	in ³
Average Core Power Density	2501.670892	Btu/hr/in ³
Fuel Weight	304237.9218	lb
Specific Power	40085984.54	Btu/hr/lbU
Burnup	10214961312	Btu/lbU
Number of Fuel Assemblies	732	
Fuel Element Array	8x8	
Assembly Dimensions	5.52/5.52	in, in
Assembly Pitch	0.1524	
Number of Fuel Rods/Assembly	62	
Total Number of Fuel Rods	45384	
Fuel Rod O.D.	0.493	in
Fuel Rod Pitch	0.64	in
Pitch/Diameter	1.3	
Clad Thickness	0.034	in
Fuel Pellet Diameter	0.416	in
Pellet-Clad Gap	0.0045	in
Fuel Enrichment	2.2-2.7%	
Pellet Density % Theoretical	~94%	
Fission Gas Plenum Length	13.41732283	in
System Pressure	1040.000001	psi
Coolant Flow	29166.71636	lb/s
Core Inlet Enthalpy	527.9	Btu/lb
Average Exit Quality	14.6	%
Core Average Void Fraction	42.6	%
Maximum Exit Void Fraction	76	%
Average Inlet Velocity	0.004580636	fps
Core Pressure Drop	25.90000007	psi
Average Linear Heat Rate	11847.71401	Btu/hr/in ³
Maximum Linear Heat Rate	26459.89466	Btu/hr/in ³
Average Heat Flux	158999.5334	Btu/hr ft ²
Maximum Heat Flux	353998.9602	Btu/hr ft ²
Minimum CHFR	>1.9	
Inlet Temperature (Feedwater) Core Inlet Temperature	419.999	F
Core Inlet Temperature	5031.986	F
Outlet Temperature	5208.9998	F
Maximum Fuel Temperature	3499.988	F

Table 1.8**Design parameters for HTGR**

Core Thermal Power	10236424905	Btu/hr
Plant Electrical Output	3992205713	Btu/hr
Plant Efficiency	39	%
Steam Temperature	950	F
Steam Pressure	2500	psi
Coolant	Helium	
Coolant Pressure	700.000002	psi
Number of Steam Generators	6	
Number of Auxiliary Generators	3	
Pressure Vessel Material	Reinforced Concrete	
PCR V Height	1092	in
PCR V Diameter	1200	in
PCR V Weight	90000000	lb
Weight of Core	6000000	lb

Table 1.9**HTGR core geometry and thermal hydraulic characteristics**

Thermal Output	10236424905	Btu/hr
Core Active Height	249.6	in
Core Diameter	333.6	in
Height/Diameter	0.75	
Active Core Volume	21599999.98	in ³
Average Core Power Density	473908.561	Btu/hr/in ³
Fuel Type	UC, ThO ₂	
Fuel Weight (U and Th)	85980.28225	lb
Uranium Weight	3968.320719	lb
Specific Power	92818.87251	Btu/hr/in ³
Average Burnup	3640240758	Btu/lbU-Th
Number of Core Stacked Columns	493	
Number of Fuel Elements per Column	80	
Number of Fuel Elements per Column	3944	
Fuel Element Geometry	Hexagonal shape 0.7874 m high, 0.36068 m across flats	
Fuel Rods per Element	132	
Fuel Rod Diameter	0.63	in
Fuel Enrichment	93.5	% of U235
System Pressure	4826330.11	psi
Coolant Flow	3055.555564	lb/s
Coolant Inlet Temperature	635.99	F
Coolant Outlet Temperature	1376.996	F
Coolant Channels per Fuel Element	72	
Coolant Channel Diameter	0.825	in
Average Heat Flux	64799.8098	Btu/hr ft ²
Maximum Heat Flux	184999.4573	Btu/hr ft ²
Maximum Fuel Temperature	2570	F