1.3 Comparison Tables

This section highlights the principal design features of the Lungmen Nuclear Power Station (NPS) and compares its major features with those of other BWR facilities. The design of this facility is based on proven technology obtained during the development, design, construction, and operation of BWRs of similar types. The data, performance characteristics, and other information presented here represent a current, firm design.

1.3.1 Nuclear Steam Supply System Design Characteristics

Table 1.3-1 summarizes the design and operating characteristics for the nuclear steam supply systems. Parameters are related to power output for a single plant unless otherwise noted.

1.3.2 Engineered Safety Features Design Characteristics

Table 1.3-2 compares the engineered safety features design characteristics.

1.3.3 Containment Design Characteristics

Table 1.3-3 compares the containment design characteristics.

1.3.4 Structural Design Characteristics

Table 1.3-4 compares the structural design characteristics.

Table 1.3-1 Comparison of Nuclear Steam Supply System Design Characteristics

Design[1]	Lungmen NPS 278-872	ABWR SSAR 278-872[2]	NMP-2 BWR/5 251-764	Grand Gulf BWR/6 251-800
Thermal and Hydraulic (Section 4.4)				
Rated power (MWt)	3926	3926	3323	3833
Design power (MWt) (ECCS design basis)	4005	4005	3463	4025
Steam flow rate, Mlb/hr at 420°F (FW Temp)	16.843	16.843	14.263	16.491
Core coolant flow rate (Mlb/hr)	115.1	115.1	108.5	112.5
Feedwater flow rate (Mlb/hr)	16.807	16.807	14.564	16.455
System pressure, nominal in steam dome (psia)	1040	1040	1020	1040
Average power density (kW/l)	49.2	50.0	49.15	54.1
Maximum linear heat generation rate (kW/ft)	11.8	13.4	13.4	13.4
Average linear heat generation rate (kW/ft)	4.16	5.97	5.40	5.93
Maximum heat flux (Btu/hr/ft^2)	380,775	361,600	354,255	361,600
Average Heat flux (Btu/hr/ft^2)	134,239	161,100	144,032	160,300
Maximum UO_2 temperature (°F)	2529	3365	3325	3435
Average volumetric fuel temperature (°F)	1645	2150	2130	2185
Average cladding surface temperature (°F)	565	566	566	565
Minimum critical power ratio (MCPR)	1.31	1.17	1.24	1.20
Coolant enthalpy at core inlet (Btu/lb)	527.7	527.7	527.5	527.9
Core maximum voids within assemblies	75	75	76.2	76
Core average exit quality (% steam)	14.6	14.5	13.1	14.6
Feedwater temperature (°F)	420	420	420	420
Nuclear (first core) (Section 4.3)				
Water/UO_2 volume ratio (cold)	2.90	2.95	2.55	2.70
Reactivity with strongest control rod out (k_{eff})	<0.99	<0.99	<0.99	<0.99
Initial average U-235 enrichment (%)	2.00	2.22	1.90	1.70

Table 1.3-1 Comparison of Nuclear Steam Supply System Design Characteristics (Continued)

Design[1]	Lungmen NPS 278-872	ABWR SSAR 278-872[2]	NMP-2 BWR/5 251-764	Grand Gulf BWR/6 251-800
Initial cycle exposure (MWd/short ton)	9600	9950	9200	7500
Fuel Assembly (Section 4.2)				
Number of fuel assemblies	872	872	764	800
Fuel rod array	10 x 10	8 x 8	8 x 8	8 x 8
Overall length (inches)	176	176	176	176
Weight of UO_2 per assembly (lb) (pellet type)	403	435	466	458
Weight of fuel assembly (lb) (includes channel)	662	675	698	697
Fuel Rods (Section 4.2)				
Number of fuel rods per assembly	92	62	63	62
Outside diameter (in.)	0.404	0.483	0.493	0.483
Cladding thickness (in.)	[3]	[3]	0.032	0.032
Diametral gap, pellet-to-cladding (in.)	[3]	[3]	0.009	0.009
Length of gas plenum (in.)	[3]	[3]	14	9.48
Cladding material[4]	Zircaloy-2	Zircaloy-2	Zircaloy-2	Zircaloy-2
Fuel Pellets (Section 4.2)				
Material	UO_2	UO_2	UO_2	UO_2
Density (% of theoretical)	[3]	[3]	95	95
Diameter (in.)	[3]	[3]	0.416	0.410
Length (in.)	[3]	[3]	0.420	0.410
Fuel Channel (Section 4.2)				
Thickness (in.) corner/wall	0.100/0.065	0.100	0.100	0.120
Cross section dimensions (in.)	5.52 x 5.52	5.48 x 5.48	5.48 x 5.48	5.45 x 5.45
Material	Zircaloy-2	Zircaloy-4	Zircaloy-4	Zircaloy-4
Core Assembly (Section 4.2)				
Fuel weight as UO_2 (lb)	351,262	379,221	265,551	365,693
Core diameter (equivalent) (in.)	203.3	203.3	160.2	191.5
Core height (active fuel) (in.)	150	146	146	150
Reactor Control System (Chapters 4 and 7)				

Table 1.3-1 Comparison of Nuclear Steam Supply System Design Characteristics (Continued)

Design[1]	Lungmen NPS 278-872	ABWR SSAR 278-872[2]	NMP-2 BWR/5 251-764	Grand Gulf BWR/6 251-800
Method of variation of reactor power	Movable control rods and variable forced coolant flow	Movable control rods and variable forced coolant flow	Movable control rods and variable forced coolant flow	Movable control rods and variable forced coolant flow
Number of movable control rods	205	205	185	193
Shape of movable control rods	Cruciform	Cruciform	Cruciform	Cruciform
Pitch of movable control rods	12.2	12.2	12.0	12.0
Control material in movable rods	B_4C granules compacted in SS tubes and hafnium	B_4C granules compacted in SS tubes	B_4C granules compacted in SS tubes	B_4C granules compacted in SS tubes
Type of control rod drives	Bottom entry electric hydraulic fine motion	Bottom entry locking piston	Bottom entry locking piston	Bottom entry locking piston
Type of temporary Reactivity control for initial core	Burnable poison; gadolinia-urania fuel rods	Burnable poison; gadolinia-urania fuel rods	Burnable poison; gadolinia-urania fuel rods	Burnable poison; gadolinia-urania fuel rods

Table 1.3-1 Comparison of Nuclear Steam Supply System Design Characteristics (Continued)

Design[1]	Lungmen NPS 278-872	ABWR SSAR 278-872[2]	NMP-2 BWR/5 251-764	Grand Gulf BWR/6 251-800
Incore Neutron Instrumentation (Chapters 4 and 7)				
Total number of LPRM detectors	208	208	172	176
Number of incore LPRM penetrations	52	52	43	44
Number of LPRM detectors per penetration	4	4	4	4
Number of SRM penetrations	N/A	N/A	4	6
Number of IRM penetrations	N/A	N/A	8	8
Number of SRNM penetrations	10	10	N/A	N/A
Total nuclear instrument penetrations	62	62	43	58
Source range monitor range (SRM)	N/A	N/A	[6]	[6]
Intermediate range monitor range (IRM)	N/A	N/A	[6]	[6]
Startup range neutron monitor range (SRNM)	[5,6]	[5,6]	N/A	N/A
Power range monitors range	Approximately 1% power to 125% power			
Local power range monitors	208	208	172	176
Average power range monitors	4	4	6	8
Number and type of incore neutron source	5 CF	5 Sb-Be	7 Sb-Be	7 Sb-Be
Reactor Vessel (Section 5.3)				
Material	Low-alloy steel/ stainless and Ni-Cr-Fe alloy clad	Low-alloy steel/ stainless clad and Ni-Cr-FE alloy clad	Low-alloy steel/ stainless clad	Low-alloy steel/ stainless clad
Design pressure (psig)	1250	1250	1250	1250
Design temperature (°F)	575	575	575	575
Inside diameter (ft-in.)	23-2	23-2	20-11	20-11
Inside height (ft-in.)	68-11	68-11	72-5	72-7
Minimum base metal thickness (cylindrical section) (in.)	7.50	7.50	6.19	6.19
Minimum cladding thickness (in.)	1/8	1/8	1/8	1/8

Table 1.3-1 Comparison of Nuclear Steam Supply System Design Characteristics (Continued)

Design[1]	Lungmen NPS 278-872	ABWR SSAR 278-872[2]	NMP-2 BWR/5 251-764	Grand Gulf BWR/6 251-800
Reactor Coolant Recirculation (Chapter 5)				
Number of recirculation loops	0	0	2	2
Design pressure				
inlet leg (psig)	N/A[7]	N/A[7]	1650	1250
outlet leg (psig)	N/A[7]	N/A[7]	1650[9] 1550	1650[8] 1550[9]
Design temperature (°F)	N/A[7]	N/A[7]	575	575
Pipe diameter (in.)	N/A[7]	N/A[7]	24	24
Pipe material (ASME)	N/A[7]	N/A[7]	316k	304/316
Recirculation pump flow rate (gpm)	30,430/ pump	30,430/ pump	47,200	44,600
Number of jet pumps in reactor	N/A	N/A[7]	20	24
Main Steamlines (Subsection 5.4.9)				
Number of steamlines	4	4	4	4
Design Pressure(psig)	1250	1250	1250	1250
Design temperature (°F)	575	575	575	575
Pipe diameter (in.)	28	28	26/28	28
Pipe material	Carbon steel	Carbon steel	Carbon steel	Carbon steel

1 English units are utilized in this table since the data obtained from the comparative BWR operating facilities are in English units.
2 Parameters for the core loading in SSAR Figure 4.3-1 used in the sensitivity analysis
3 Proprietary information provided in a separate proprietary volume.
4 Free-standing loaded tubes.
5 Shutdown through criticality.
6 Prior criticality to low power.
7 Design utilizes reactor internal pumps (RIPs).
8 Discharge piping from discharge block valve to vessel.
9 Pump and discharge piping to and including discharge block valve.

Table 1.3-2 Comparison of Engineered Safety Features Design Characteristics

System/Component[1]	Lungmen NPS 278-872	ABWR SSAR 278-872	NMP-2 BWR/5 251-764	Grand Gulf BWR/6 251-800
Emergency Core Cooling Systems (sized on design power-Section 6.3)				
Low Pressure Core Spray Systems[2]				
Number of loops	N/A	N/A	1	1
Flow rate(gpm)	N/A N/A	N/A N/A	6350 at 128 psid	7000 at 122 psid
High Pressure Core Spray System[3]				
Number of loops	2	2	1	1
Flow rate (gpm)	800 at 1177 psid	800 at 1177 psid	1550 at 1130 psid	1650 at 1147 psid
	3200 at 100 psid	3200 at 100 psid	6350 at 200 psid	7000 at 200 psid
Reactor Core Isolation Cooling System (Subsection 5.4.6)				
Flow rate (gpm)	800 at 165-1192 psia reactor pressure	800 at 165-1192 psia reactor pressure	600 at 1173 psia reactor pressure	800 at 165-1192 psia reactor pressure
Automatic Depressurization System				
Number of relief valves	8	8	7	8
Low Pressure Coolant Injection[4]				
Number of loops	3	3	3	3
Number of pumps	3	3	3	3
Flow rate (gpm/pump)	4200 at 40 psid	4200 at 40 psid	7450 at 26 psid	7450 at 20 psid

Table 1.3-2 Comparison of Engineered Safety Features Design Characteristics (Continued)

System/Component[1]	Lungmen NPS 278-872	ABWR SSAR 278-872	NMP-2 BWR/5 251-764	Grand Gulf BWR/6 251-800
Auxiliary Systems Residual Heat Removal System (Subsection 5.4.7)				
Reactor shutdown cooling mode				
Number of loops	3	3	2	2
Number of pumps [5]	3	3	2	2
Flow rate (gpm/pump)	4200	4200	7450	7450
Duty (MBtu/ hr heat exchanger)[6]	29.0	29.0	41.6	50.0
Number of heat exchangers	3	3	2	2
Primary containment cooling mode flow rate (gpm)	4200	4200	7450	7450
Flow rate (gpm/heat exchanger)	8000	8000	7400	25,300 total
Number of pumps	3 loops RBCW	3 loops RCW	6	2 at 12,000 gpm 1 at 1300 gpm
Fuel Pool Cooling and Cleanup System (Subsection 9.1.3)				
Capacity (MBtu/hr)	6.55	6.55	15.0	11.8

1 English units are utilized in this table since the data obtained from the comparative BWR operating facilities are in English units.

2 ABWR design utilizes the low pressure flooder mode of the RHR System.

3 ABWR design is a flooder system not a spray system.

4 ABWR design referred to as Low Pressure Flooder.

5 The design of the pumps is, in part, based on the required capacity during the reactor flooding mode.

6 Heat exchanger duty at 20 hours after reactor shutdown.

Table 1.3-3 Comparison of Containment Design Characteristics

Containment[1, 2]	Lungmen NPS 278-872	ABWR SSAR 278-872	NMP-2 BWR/5 251-764	Grand Gulf BWR/6 251-800
Primary				
Type	Over- and underpressure suppression	Over- and underpressure suppression	Over- and under-pressure Suppression Mark II	Mark III reinforced concrete containment with steel liner
Construction	Reinforced concrete with steel liner; steel structure	Reinforced concrete with steel liner; steel structure	Reinforced concrete with steel liner	Reinforced concrete cylinder with hemispherical head; steel lined
Drywell	Concrete cylinder	Concrete cylinder	Frustum of cone upper portion	Concrete cylinder[3]
Pressure suppression chamber	Concrete cylinder	Concrete cylinder	Cylindrical lower portion	Steel lined concrete annulus
Containment internal design pressure (psig)	45	45	45	15
Drywell internal design pressure (psig)	45	45	45	30
Drywell free volume (ft^3)	259,563	259,563	303,418	270,000
Pressure suppression chamber free volume (ft^3)(HWL)	210,475	210,475	192,028	1,400,000
Pressure suppression pool water volume (ft^3)(LWL)	126,426	126,426	154,794	136,000 (upper pool dump = 72,800)
Submergence of vent pipe below suppression pool surface (ft) (HWL)	11.8 to 20.8	11.8 to 20.8	11.0 max.	7.5 min.
Design temperature of drywell (°F)	340	340	340	330
Downcomer vent pressure loss factor	2.5–3.5	2.5–3.5	1.37	2.5–3.5
Break area/ total vent area	0.01	0.01	0.0108	0.008

Table 1.3-3 Comparison of Containment Design Characteristics (Continued)

Containment[1, 2]	Lungmen NPS 278-872	ABWR SSAR 278-872	NMP-2 BWR/5 251-764	Grand Gulf BWR/6 251-800
Primary (Continued)				
Calculated maximum drywell pressure after blowdown (psig).	39	39	39.7	22.0
Pressure suppression chamber (psig)	26	26	34.0	9.0
Initial pressure suppression pool temperature rise (°F) during LOCA	50	50	50	30
Leakage rate (% free volume/day)	0.5	0.5	1.1	0.35
Secondary				
Type	Controlled leakage	Controlled leakage	Controlled leakage elevated release	Controlled leakage
Construction				
Lower levels	Reinforced concrete	Reinforced concrete	Reinforced concrete	Reinforced concrete
Upper levels	Reinforced concrete	Reinforced concrete	Steel superstructure and siding	Steel superstructure and siding
Roof	Reinforced concrete	Reinforced concrete	Steel decking	Steel decking
Design in leakage rate (% free volume/day at 0.25 in. H_2O)	50	50	100	100

1 English units are utilized in this table since the data obtained from the comparative BWR operating facilities are in English units.

2 Where applicable, containment parameters are based on design rated power.

3 Not part of containment boundary.

Table 1.3-4 Comparison of Structural Design Characteristics

	Lungmen NPS 278-872	ABWR SSAR 278-872	NMP-2 BWR/5 251-764	Grand Gulf BWR/6 251-800
Seismic Design (Section 3.7)[1]				
Operating Basis Earthquake				
horizontal g	0.20	None	0.075	0.075
vertical g	0.20	None	0.075	0.05
Safe Shutdown Earthquake				
horizontal g	0.40	0.30	0.15	0.15
vertical g	0.40	0.30	0.15	0.10
Wind Design (Subsection 3.3.2)				
Translation (mph)	156.5	60	70	60
Tangential (mph)	N/A	240	290	300

1 English units are utilized in this table since the data obtained from the comparative BWR operating facilities are in English units.