




<b>UK EPR</b>	Title: PCSR – Sub-chapter 1.3 – Comparison with reactors of similar design	
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02	PCSR June 2009 update: Design evolutions to account for December 2008 design freeze (primary and secondary flow rates, temperatures, SG water mass) and clarifications/ rewording.	22-06-2009
03	Consolidated Step 4 PCSR update: <ul style="list-style-type: none"> <li>- Addition of non-computerised technology in I&amp;C</li> <li>- Wording correction for Remote Shutdown Station</li> </ul>	25-03-2011

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## **SUB-CHAPTER 1.3 – COMPARISON WITH REACTORS OF SIMILAR DESIGN**

Sub-chapter 1.3 consists of a comparison table of the main data for the UK EPR against the equivalent data for the latest generations of reactors built in France (N4 Reactors) and Germany (KONVOI Reactors), from which the EPR design is derived.

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SYSTEMS / PARAMETERS	UNIT	UK EPR	N4 Unit	KONVOI Reactor
<b>GENERAL REMARKS</b>				
Net electrical output	MW(e)	≈1630	1475	1365
Thermal power output (core)	MWth	4500	4250	3850
Efficiency	%	36	34.5	35.4
Service life	Years	60	40	40
Temperature programme		The average core temperature is constant in the upper power range (between 60% and 100% of the nominal power)	Linear reduction in average core temperature between 100% and 0% of power (the cold leg temperature varies slightly in a ≤4°C range)	The average core temperature is constant in the upper power range (between 50% and 100% of the nominal power)
<b>MAIN PRIMARY SYSTEM (RCP) [RCS]</b>				
Number of loops		4	4	4
Operating pressure of RCP [RCS]	MPa	15.5	15.5	15.8
Design pressure of RCP [RCS]	MPa	17.6	17.2	17.6
Vessel inlet temperature in nominal conditions	°C	295.6	292.1	291
Vessel outlet temperature in nominal conditions	°C	329.8	329.1	324.5
<b>SECONDARY SIDE</b>				
Feed water temperature at 100% power	°C	230	229.5	218
Steam pressure at SG outlet (abs) at 100% power	MPa	7.71	7.23	6.45
Main steam flow rate	kg/s	2552.4 (4x638.1)	2400	2050

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SYSTEMS / PARAMETERS	UNIT	UK EPR	N4 Unit	KONVOI Reactor
<b>REACTOR CORE</b>				
<b><i>Fuel assembly</i></b>				
Control principles at Nominal Power		Mixed solution: X-N4 mode / S-Konvoi mode: Only "black" rods Separation of control rods / shutdown rods	X mode: 4 "grey" partially inserted units A mode: No control rods inserted deeply	S Mode: Only "black" rods No separation of control rods / shutdown rods
Geometry of fuel assemblies		17X17-24	17X17-25	18X18-24
Number of fuel assemblies		241	205	193
Number of control rods		89 (black control rods only)	73 (65 black control rods and 8 grey)	61 (black control rods only)
Active length of fuel assembly (in cold service conditions)	mm	4200	4270	3900
Total length of fuel assembly	mm	4800	4800	4830
<b><i>Fuel rods</i></b>				
Number of rods		63865 (265 rods / assembly)	54120	57900
External diameter	cm	0.95	0.95	0.95
Network pitch	cm	1.26	1.26	1.27
Gross average power density per unit length	W/cm	167.7	183.9	170.5
Cladding thickness	cm	0.057	0.057	0.0641
<b><i>Fuel pellets</i></b>				
Composition		UO <sub>2</sub> or MOX	UO <sub>2</sub>	UO <sub>2</sub> or MOX
Max design enrichment U 235	%	5	5	4

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<b>SYSTEMS / PARAMETERS</b>	<b>UNIT</b>	<b>UK EPR</b>	<b>N4 Unit</b>	<b>KONVOI Reactor</b>
Average discharge burnup	MWd /kgU	>55 (for 18-month cycles) to <65 (for 24-month cycles)	40	50
MOX capacity		30 % as design basis	No MOX operation on the N4 currently	yes (50 %)
<b>Structure of core</b>				
Core baffles		Heavy reflector	Bolted baffle	Welded baffles
<b>Primary coolant flow rate</b>				
Total mass flow rate under thermal-hydraulic conditions	kg/s	22235	19714	18800
Mass flow rate in core under nominal best estimate conditions	kg/s	23135	20193	19875
<b>Core instrumentation</b>				
Ex-core instrumentation		Neutron flux measurement channels	Neutron flux measurement channels	Neutron flux measurement channels
In-core instrumentation		“assembly on vessel head” 40 aero-ball probes 12 fixed Self Powered Neutron Detector fingers for a total of 72 neutron detectors and 36 (12x3) fixed core exit thermocouples	“assembly from bottom of vessel” 6 mobile fission measurement detectors 60 instrumented fuel assemblies 52 core exit thermocouples	“assembly on vessel head” 28 aero-ball probes 8 fixed neutron detector fingers 48 (8x6) detectors 24(8x3) core exit thermocouples
<b>REACTOR PRESSURE VESSEL</b>				
<b>Vessel Design</b>				
Design temperature	°C	351	343	350
Internal diameter at core level	Mm	4870	4486	5000

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SYSTEMS / PARAMETERS	UNIT	UK EPR	N4 Unit	KONVOI Reactor
<b>PRIMARY PUMPS</b>				
Flow rate (Best Estimate – design value)	m <sup>3</sup> /h	28320	24850	22700
<b>STEAM GENERATORS</b>				
Secondary pressure boundary design pressure	MPa	10.0	9.1	8.83
Steam pressure at hot shutdown (0%NP)	MPa	9.0	≈ 8.1	≈ 8.0
Saturation pressure at full power at SG tube bundle outlet	MPa	7.8	7.31	6.55
Water mass in secondary section of Steam Generator at full load	t	77.2	62	46
<b>COOLING SYSTEM AT SHUTDOWN</b>				
Location of cooling system at shutdown		Outside Reactor Building	Inside Reactor Building	Outside Reactor Building
Number of pumps		4 (LHSI pumps)	2	4 mixed with LHSI
<b>PRESSURISER</b>				
Surge line connection on the pressuriser		Axial Vertical	Axial Vertical	Lateral Horizontal
Internal volume (hot)	m <sup>3</sup>	75	60	65
<b>MAIN PRIMARY SYSTEM</b>				
Accounting for Break Preclusion		Yes	No	Yes
<b>DESIGN OF RIS/RRA [SIS/RHRS]</b>				
<b>Medium-Head Safety Injection (MHSI) pumps</b>				
Number of pumps		4	2 via a header	4
Injection of the MHSI		In cold leg	In cold leg	In cold leg / hot leg

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<b>Low-Head Safety Injection (LHSI) pumps</b>				
Number of pumps		4	2 via a header	4
Injection of the LHSI		In cold leg (short term) and hot leg (long term)	In cold leg for the short term (hot and cold for the long term)	In cold and hot leg
<b>Accumulators</b>				
Number of accumulators		4	4	8
Location of injection		In cold leg	In cold leg	In cold and hot leg
<b>BORATION SYSTEM</b>				
System used in normal operation		Chemical and Volume Control System (RCV) [CVCS]	Chemical and volume control system (RCV) [CVCS]	Chemical and volume control system (RCV) [CVCS]
Safety system		Extra Boration System (2 trains) RBS [EBS]	Chemical and volume control system (RCV) [CVCS] Use of RCV [CVCS] for long-term phase (manual phase) medium-pressure RIS [SIS] system and RCP [RCS] discharge (through pressuriser safety valve if the RCV [CVCS] is unavailable or ineffective)	Additional boration system (4 trains)
<b>FEEDWATER SYSTEMS</b>				
Under normal operation		Main Feed Water Supply system (ARE) [MFWS]	Main Feed Water Supply system (ARE) [MFWS]	Main Feed Water Supply (ARE) [MFWS]
In the shutdown and startup phases		Dedicated AAD [SSS] system for shutdown and startup operations (1 pump)	Use of ASG [EFWS] emergency supply system	Dedicated system for shutdown and startup operations with 2 pumps, both supplied by a backed-up power supply

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Incidental and accidental conditions		Emergency Feed Water Supply system (ASG [EFWS])  4 separate, independent trains with passive headers  The pumps are driven by electric motors backed up by the emergency diesel generators and the two SBO diesel generators	Emergency Feed Water Supply system (ASG [EFWS])  4 pumps via headers (2 by 2)  2 electrical pump-motor units 2 turbo-pumps	Emergency Feed Water Supply system  4 separate, independent trains with passive headers  Each pump is driven by: - diesel (directly) and - electric motor (without backup supply)
<b>SPENT FUEL POOL COOLING SYSTEM (PTR [FPCS])</b>				
Volume of fuel pool	m <sup>3</sup>	≈ 1590	1150	
Number of pumps		2 main lines (2 pumps per main line) and an emergency line (1 pump)	2 lines (1 pump for each train)	
Nominal mass flow rate	Kg/s	Cooling pumps for main lines: 222 Backup pump: 153	Cooling pumps: 105.6	
<b>COMPONENT COOLING WATER SYSTEM (RRI [CCWS])</b>				
		4 trains (1 pump per train, 1 100% heat exchanger per train)	2 lines (2 pumps per train, 2 50% heat exchangers per train)	
<b>ESSENTIAL SERVICE WATER SYSTEM (SEC [ESWS])</b>				
Number of pumps		4 (4 trains)	4 (2 trains, 2 100% pumps / train)	
<b>ELECTRICAL SYSTEMS</b>				
Supply under normal operation		4 independent trains in 2 divisions	2 independent trains in 2 divisions	4 independent trains in 4 divisions

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Emergency supplies		<p>Concept of 4 trains, 4 divisions</p> <p>4 Emergency Diesels Generators with a power yield of about <math>\approx</math> 7MWe each located in two geographically separated buildings (10 kV) 2 Station Black Out (SBO) Diesels (690 V).</p> <p>Diversity through different generators' designs (10kV, 690 V) and fuelling</p>	<p>Concept of 2 trains, 2 divisions</p> <p>2 diesel generators each of 8MWe in two separate buildings</p> <p>Diversity of 2 diesels through the addition: of a 135kW turbine generator for short-term operation supplied by secondary steam and of a 7MWe gas turbine for the long term</p>	<p>Concept of 4 trains, 4 divisions</p> <p>4 diesel generators (each of 5MWe) in dedicated buildings and 4 ultimate diesels (each of 0.96kVA) in completely protected separate buildings</p> <p>Diversity through size of the different diesel generators</p>
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SYSTEMS / PARAMETERS	UNIT	UK EPR	N4 Unit	KONVOI Reactor
<b>INSTRUMENTATION AND CONTROL</b>				
Technology		Digital (preferably "market" components) and non-computerised (NCSS)	Digital	Analogous, hard-wired. Digital and computer technology for certain applications
Main Control Room		Control through computer screens (except for the safety control panel) Protected against external hazards	Control through computer screens (except for the safety control panel) Protected against external hazards	Conventional with a digital assistance system Protected against external hazards
Remote shutdown station		Remote shutdown station with computer screens to bring the reactor to and maintain it in a safe state should the Main Control Room be unavailable  Protected against external hazards	Remote shutdown station to bring the reactor to and maintain it in a safe state should the Main Control Room be unavailable  Protected against external hazards	Backup control room (in a separate building) to keep the reactor in a safe state should the main control room be unavailable  Protected against external hazards
<b>CONTAINMENT</b>				
Internal containment		Pre-stressed concrete with steel liner	Pre-stressed concrete no liner	Spherical steel containment
External wall		Reinforced concrete Annulus space at sub-pressure	Reinforced concrete Annulus space at sub-pressure	Reinforced concrete Annulus space at sub-pressure
Containment spray operation for PCCs		No	Yes 2 (100%) lines – pumps and heat exchangers outside containment	No
Pressure control system for Severe Accidents		Containment Heat Removal System 2 trains	Containment venting with filtering	Containment venting with filtering
Internal volume	m <sup>3</sup>	≈ 80000	72700	70000

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SYSTEMS / PARAMETERS	UNIT	UK EPR	N4 Unit	KONVOI Reactor
<b>WATER STORAGE TANK</b>				
Location		In-Containment Refuelling Water Storage Tank (IRWST) located inside the Reactor Building	PTR [FPPS/FPCS] tank located outside the Reactor Building	Inside the annulus
Number		1	1	4