

## 8. AUXILIARY SYSTEMS

### 8.1. Coolant purification system

#### Experimental Fast Reactors

Plant	Coolant purification system			
	Number of cold traps		Main coolant for	
	Primary	Secondary	Primary circuit cold trap	Secondary circuit cold trap
Rapsodie (France)	2	1 per loop	nitrogen	air
KNK-II (Germany)	-	-	-	-
FBTR (India)	1	2	organic liquid	organic liquid
PEC (Italy)	1 (1*)	2 (1*)	organic liquid	air (air*)
JOYO (Japan)	2	1	nitrogen gas	air
DFR (UK)	17	24	air	air
BOR-60 (Russian Federation)	2	2	water	air
EBR-II (USA)	1	1	NaK	organic liquid
Fermi (USA)	1	1	NaK	NaK
FFTF (USA)	1	3	NaK	air
BR-10 (Russian Federation)	1	2	organic liquid and water	
CEFR (China)	2	2	organic liquid/Na-K alloy	

#### Demonstration or Prototype Fast Reactors

Phénix (France)	2	1 per loop	organic liquid	organic liquid
SNR-300 (Germany)	4	3	-	-
PFBR (India)	2	2	nitrogen gas	air
MONJU (Japan)	2	6	nitrogen gas	air
PFR (UK)	1	1	air	air
CRBRP (USA)	2	6	NaK	gas blower
BN-350 (Kazakhstan)	6	6	NaK	NaK
BN-600 (Russian Federation)	4	6	gas	gas
ALMR (USA)	6	6	nitrogen gas	air
KALIMER-150 (Republic of Korea)	not yet decided		gas	gas
SVBR-75/100 (Russian Federation)	hydrogen regeneration of lead oxides, insoluble impurities filtration			
BREST-OD-300 (Russian Federation)	4 filters and hydrogen regeneration of lead oxides			no sec. loop

\* test channel

## 8. AUXILIARY SYSTEMS (cont.)

### 8.1. Coolant purification system

#### Commercial Size Reactors

Plant	Coolant purification system			
	Number of cold traps		Main coolant for	
	Primary	Secondary	Primary circuit cold trap	Secondary circuit cold trap
Super-Phénix 1 (France)	2	1 per loop	nitrogen gas	organic liquid
Super-Phénix 2 (France)	1	1 per loop	gas	gas
SNR 2 (Germany)	-	-	-	-
DFBR (Japan)	3	2 per loop	nitrogen gas	air
CDFR (UK)	1	4	air	air
BN-1600 (Russian Federation)	2	6	gas	gas
BN-800 (Russian Federation)	3	6	air	air
EFR	1	6	nitrogen gas	air
ALMR (USA)	6	6	nitrogen gas	air
SVBR-75/100 (Russian Federation)	hydrogen regeneration of lead oxides, insoluble impurities filtration			
BN-1800 (Russian Federation)	2	6	air	air
BREST-1200 (Russian Federation)	4 filters and hydrogen regeneration of lead oxides			no sec. loop
JSFR-1500 (Japan)	2	4	nitrogen gas	air

## 8. AUXILIARY SYSTEMS (cont.)

### 8.1. Coolant purification system

#### Experimental Fast Reactors

Plant	Coolant purification system					
	Volume of mesh region in cold trap (m <sup>3</sup> )		Maximum permissible impurity concentration (primary) (ppm)			Maximum acceptable plugging temperature in primary circuit (s) (°C)
	Primary	Secondary	Oxygen	Hydrogen	Carbon	
Rapsodie (France)	0.18	0.18	-	-	-	130
KNK-II (Germany)		-	-	-	-	130
FBTR (India)	0.2	0.2	10	-	-	-
PEC (Italy)	not defined	7 (7*)	not defined			
JOYO (Japan)	1.15	0.764	12	-	-	-
DFR (UK)	0.5	0.75	5	-	-	-
BOR-60 (Russian Federation)	0.3	0.3	10	0.5	30.0	150.0
EBR-II (USA)	0.068**	0(meshless)	5.4***	0.46***	no limit	
Fermi (USA)	1.5	1.5	-	-	-	130
FFTF (USA)	1.55	0.74****	5	0.4	-	0.01
BR-10 (Russian Federation)	0.052	0.052	50	-	20	160
CEFR (China)	1.65/2.9	1.65	10	0.5	20	150

#### Demonstration or Prototype Fast Reactors

Phénix (France)	2	3	-	-	-	150
SNR-300 (Germany)	-			-	-	-
PFBR (India)	2.5	9.2	3.0	1.0	25	150
MONJU (Japan)	1.35	5	10	0.17	-	-
PFR (UK)	1.2	1.0	10	0.3	-	150
CRBRP (USA)	1.70	2.69	2(427°C): 0.2/5	(427°C): 0.3	-	-
BN-350 (Kazakhstan)	3	3	10	6	40	150
BN-600 (Russian Federation)	6.8*****	6.8	10	0.5	10	150
ALMR (USA)	2.8	8.7	10	-	-	-
KALIMER-150 (Republic of Korea)	not yet decided					
SVBR-75/100 (Russian Federation)	lead-bismuth coolant		-	-	-	
BREST-OD-300 (Russian Federation)	lead coolant		0.04-3.25		-	-

\* test channel

\*\* seven 0.0097 m<sup>3</sup> mesh cylinders

\*\*\* based on 350°F limit on plugging temperature

\*\*\*\* per trap

\*\*\*\*\* volume of the cold trap

\*\*\*\*\* unplugging temperature

## 8. AUXILIARY SYSTEMS (cont.)

### 8.1. Coolant purification system

#### Commercial Size Reactors

Plant	Coolant purification system					
	Volume of mesh region in cold trap (m <sup>3</sup> )		Maximum permissible impurity concentration (primary) (ppm)			Maximum acceptable plugging temperature in primary circuit (s) (°C)
	Primary	Secondary	Oxygen	Hydrogen	Carbon	
Super-Phénix 1 (France)	0.4	2.8	3	0.25	50	155*****
Super-Phénix 2 (France)				3	50	
SNR 2 (Germany)	not determined					
DFBR (Japan)	1.5	7.0	10			
CDFR (UK)	not determined					
BN-1600 (Russian Federation)	10	1.9	10	0.5	15	150
BN-800 (Russian Federation)	6.5	6.5	10	0.5	15	150
EFR	1.5	2.1	5	0.3	50	150
ALMR (USA)	2.8	8.7	10	-	-	-
SVBR-75/100 (Russian Federation)	lead-bismuth coolant					
BN-1800 (Russian Federation)	6.5	6.5	10	0.5	15	150
BREST-1200 (Russian Federation)	lead coolant		0.04-3.25			
JSFR-1500 (Japan)	2.2	3.4	2	-	to be determined	

\*\*\*\*\* unplugging temperature

## 8. AUXILIARY SYSTEMS (cont.)

### 8.1. Coolant purification system

#### Experimental Fast Reactors

Plant	Coolant purification system			
	Maximum permissible impurity concentration (secondary) (ppm)			Maximum acceptable plugging temperature in secondary circuit(s) (°C)
	Oxygen	Hydrogen	Carbon	
Rapsodie (France)	-	-	-	30
KNK-II (Germany)	-	-	-	-
FBTR (India)	10	0.12	-	130
PEC (Italy)	7 (7*)	not defined	-	-
JOYO (Japan)	20	-	-	-
DFR (UK)	5	-	-	-
BOR-60 (Russian Federation)	10	0.5	30.0	150
EBR-II (USA)	no limit	0.2	no limit	-
Fermi (USA)	-	-	-	150
FFTF (USA)	5	0.4	0.01	-
BR-10 (Russian Federation)	-		-	150
CEFR (China)	10	0.5	20	150

#### Demonstration or Prototype Fast Reactors

Phénix (France)	-	-	-	180
SNR-300 (Germany)	-	-	-	-
PFBR (India)	3	0.2	25	150
MONJU (Japan)	10	0.17	-	-
PFR (UK)	10	0.3	-	-
CRBRP (USA)	2	0.2	not controlled (0.3 ppm possible)	150
BN-350 (Kazakhstan)	10	6	40	150
BN-600 (Russian Federation)	10	0.5	30	150
ALMR (USA)	-	-	-	-
KALIMER-150 (Republic of Korea)	-	not yet decided	-	-
SVBR-75/100 (Russian Federation)	-	no secondary loops	-	-
BREST-OD-300 (Russian Federation)	-	no secondary loops	-	-

\* test channel

## 8. AUXILIARY SYSTEMS (cont.)

### 8.1. Coolant purification system

#### Commercial Size Reactors

Plant	Coolant purification system			
	Maximum permissible impurity concentration (secondary) (ppm)			Maximum acceptable plugging temperature in secondary circuit(s) (°C)
	Oxygen	Hydrogen	Carbon	
Super-Phénix 1 (France)	5	0.2	50	170**
Super-Phénix 2 (France)	3	-	50	-
SNR 2 (Germany)	not determined			
DFBR (Japan)	10	-	0.17	-
CDFR (UK)	not determined			
BN-1600 (Russian Federation)	10	0.5	50	150
BN-800 (Russian Federation)	10	0.1	50	150
EFR	3 (7 short-term)	<0.21		150
ALMR (USA)	-	-	-	180°C (short-term)
SVBR-75/100 (Russian Federation)	no secondary loops			
BN-1800 (Russian Federation)	10	0.1	50	150
BREST-1200 (Russian Federation)	no secondary loops			
JSFR-1500 (Japan)	5	133 ppb	to be determined	-

\*\* unplugging temperature

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Experimental Fast Reactors

Plant	Cover gas system	
	Principal function (primary)	Design principle, e.g. constant mass (CM) or constant pressure (CP)
Rapsodie (France)	VH, P, IHX	CP
KNK-II (Germany)	VH, P	-
FBTR (India)	V, P, IHX	CP
PEC (Italy)	VH, P (VH,P*)	-
JOYO (Japan)	VH, P, IHX	CP
DFR (UK)	V, LE, BV	-
BOR-60 (Russian Federation)	VH, P	CP
EBR-II (USA)	VH, P	-
Fermi (USA)	V, VH, P, IHX, LE, MS	-
FFTF (USA)	VH, P	-
BR-10 (Russian Federation)	V, LE, BV	CP
CEFR (China)	V, VH, MS	CP

#### Demonstration or Prototype Fast Reactors

Phénix (France)	V, P, IHX	CP
SNR-300 (Germany)	VH, P	-
PFBR (India)	V, LE	CP
MONJU (Japan)	VH, P, IHX	CP
PFR (UK)	VH, MS	-
CRBRP (USA)	VH, FCH, MS, P, LE	-
BN-350 (Kazakhstan)	VH, P	CP
BN-600 (Russian Federation)	VH, P	CP
ALMR (USA)	VH	-
KALIMER-150 (Republic of Korea)	VH	CP
SVBR-75/100 (Russian Federation)	V	CM
BREST-OD-300 (Russian Federation)	VH, P, LE, MS	CP

\* test channel

- V - buffers reactor vessel
- VH - buffers reactor vessel head or roof
- P - buffers pump seals
- IHX - buffers IHX
- LE&BV - buffers loop expansion tanks and bypass vessel
- MS - buffers all mechanism seals

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Commercial Size Reactors

Plant	Cover gas system	
	(secondary) (ppm)	Design principle, e.g. constant mass (CM) or constant pressure (CP)
Super-Phénix 1 (France)	VH,P,IHX,MS	CP
Super-Phénix 2 (France)	VH,P,IHX,MS	-
SNR 2 (Germany)	VH,P	-
DFBR(Japan)	VH,P,IHX	CP
CDFR (UK)	VH,P	-
BN-1600 (Russian Federation)	VH,P	CP
BN-800 (Russian Federation)	VH,P	CP
EFR	VH,P,MS	CM
ALMR (USA)	VH	CM
SVBR-75/100 (Russian Federation)	V	CM
BN-1800 (Russian Federation)	not yet decided	CM
BREST-1200 (Russian Federation)	VH, P, LE, MS	CP
JSFR-1500 (Japan)	VH, P, IHX	CP

- V - buffers reactor vessel
- VH - buffers reactor vessel head or roof
- P - buffers pump seals
- IHX - buffers IHX
- LE&BV - buffers loop expansion tanks and bypass vessel
- MS - buffers all mechanism seals

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Experimental Fast Reactors

Plant	Cover gas system	
	Principal function (secondary)	Design principle e.g. constant mass (CM) or constant pressure (CP)
Rapsodie (France)	P	-
KNK-II (Germany)	P	-
FBTR (India)	P	CP
PEC (Italy)	LE & BV, P (LE & BV*)	-
JOYO (Japan)	P	CP
DFR (UK)	LE & BV	CP
BOR-60 (Russian Federation)	P	CP
EBR-II (USA)	P	-
Fermi (USA)	P, LE, SGH, IHX	-
FFTF (USA)	P	-
BR-10 (Russian Federation)	LE & BV	CP
CEFR (China)	P, LE & BV, SGH, CT	CP

#### Demonstration or Prototype Fast Reactors

Phénix (France)	P	CP
SNR-300 (Germany)	P	-
PFBR (India)	LE	CP
MONJU (Japan)	SGH,P	CP
PFR (UK)	TP,P,V	-
CRBRP (USA)	P,LE	-
BN-350 (Kazakhstan)	SGH,P	CP
BN-600 (Russian Federation)	P,CT	CP
ALMR (USA)	LE & BV, SGH	-
KALIMER-150 (Republic of Korea)	SGH	not yet decided
SVBR-75/100 (Russian Federation)	no secondary loops	-
BREST-OD-300 (Russian Federation)	no secondary loops	-

\* test channel

- P - buffers pump seals
- LE&BV - buffers loop expansion tanks and bypass vessel
- SGH - buffers steam generator head
- TP - buffers tube plates
- V - buffers valve actuators
- CT - buffers compensation tank seals

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Commercial Size Reactors

Plant	Cover gas system	
	Principal function (secondary)	Design principle e.g. constant mass (CM) or constant pressure (CP)
Super-Phénix 1 (France)	P, LE & BV, SGH,CT	CP
Super-Phénix 2 (France)	P, LE & BV, SGH,CT	-
SNR 2 (Germany)	P	-
DFBR (Japan)	P, SGH	CP
CDFR (UK)	TP, P	-
BN-1600 (Russian Federation)	P, CT	CP
BN-800 (Russian Federation)	P, CT	CP
EFR	P, LE & BV,SGH	CP
ALMR (USA)	LE & BV, SGH	-
SVBR-75/100 (Russian Federation)	no secondary loops	-
BN-1800 (Russian Federation)	-	CM
BREST-1200 (Russian Federation)	no secondary loops	-
JSFR-1500 (Japan)	P, SGH	CP

- P - buffers pump seals
- LE&BV - buffers loop expansion tanks and bypass vessel
- SGH - buffers steam generator head
- TP - buffers tube plates
- V - buffers valve actuators
- CT - buffers compensation tank seals

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Experimental Fast Reactors

Plant	Cover gas system
	When used for the inertisation of:
Rapsodie (France)	LC
KNK-II (Germany)	LC
FBTR (India)	LC
PEC (Italy)	LC, FC (LC,FC*)
JOYO (Japan)	LC
DFR (UK)	-
BOR-60 (Russian Federation)	FC
EBR-II (USA)	FC
Fermi (USA)	LC
FFTF (USA)	LC,FC
BR-10 (Russian Federation)	P
CEFR (China)	P, FC

#### Demonstration or Prototype Fast Reactors

Phénix (France)	LC
SNR-300 (Germany)	LC
PFBR (India)	LC
MONJU (Japan)	LC
PFR (UK)	P,FC
CRBRP (USA)	LC,SGH, P
BN-350 (Kazakhstan)	FC
BN-600 (Russian Federation)	FC
ALMR (USA)	LC, P, FC
KALIMER-150 (Republic of Korea)	P, FC
SVBR-75/100 (Russian Federation)	FC
BREST-OD-300 (Russian Federation)	FC

\* test channel

LC - loop cells

P - handling flasks or pots

FC - fuel transfer cells

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Commercial Size Reactors

Plant	Cover gas system
	When used for the inertisation of:
Super-Phénix 1 (France)	P, FC
Super-Phénix 2 (France)	P, FC
SNR 2 (Germany)	LC, P
DFBR (Japan)	LC, P
CDFR (UK)	FC
BN-1600 (Russian Federation)	FC
BN-800 (Russian Federation)	FC
EFR	LC, P, FC
ALMR (USA)	LC, P, FC
SVBR-75/100 (Russian Federation)	FC
BN-1800 (Russian Federation)	not yet decided
BREST-1200 (Russian Federation)	FC
JSFR-1500 (Japan)	P, FC

- LC - loop cells
- P - handling flasks or pots
- FC - fuel transfer cells

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Experimental Fast Reactors

Plant	Cover gas system		
	Gas		Other systems
	Primary circuit(s)	Secondary circuit(s)	
Rapsodie (France)	helium	argon	nitrogen
KNK-II (Germany)	argon	argon	nitrogen
FBTR (India)	argon	argon	nitrogen
PEC (Italy)	argon	argon	argon & nitrogen
JOYO (Japan)	argon	argon	nitrogen
DFR (UK)	argon	argon	-
BOR-60 (Russian Federation)	argon	argon	nitrogen
EBR-II (USA)	argon	argon	air
Fermi (USA)	argon	argon	nitrogen
FFTF (USA)	argon	argon	nitrogen
BR-10 (Russian Federation)	argon	argon	air
CEFR (China)	argon	argon	nitrogen

#### Demonstration or Prototype Fast Reactors

Phénix (France)	argon	argon	nitrogen
SNR-300 (Germany)	argon	argon	nitrogen
PFBR (India)	argon	argon	nitrogen
MONJU (Japan)	argon	argon	nitrogen
PFR (UK)	argon	argon	argon
CRBRP (USA)	argon	argon	nitrogen
BN-350 (Kazakhstan)	argon	argon	air
BN-600 (Russian Federation)	argon	argon	air
ALMR (USA)	helium	argon	air
KALIMER-150 (Republic of Korea)	helium	argon	not yet decided
SVBR-75/100 (Russian Federation)	argon	no secondary circuits	-
BREST-OD-300 (Russian Federation)	argon	no secondary circuits	argon

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Commercial Size Reactors

Plant	Cover gas system		
	Gas		Other systems
	Primary circuit(s)	Secondary circuit(s)	
Super-Phénix 1 (France)	argon	argon	argon and nitrogen
Super-Phénix 2 (France)	argon	argon	nitrogen
SNR 2 (Germany)	argon	argon	helium
DFBR (Japan)	argon	argon	nitrogen (LC); argon (P)
CDFR (UK)	argon	argon	nitrogen
BN-1600 (Russian Federation)	argon	argon	air
BN-800 (Russian Federation)	argon	argon	air
EFR	argon	argon	nitrogen
ALMR (USA)	helium	argon	air
SVBR-75/100 (Russian Federation)	argon	no secondary circuits	-
BN-1800 (Russian Federation)	argon	argon	not yet decided
BREST-1200 (Russian Federation)	argon	no secondary circuits	argon
JSFR-1500 (Japan)	argon	argon	argon

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Experimental Fast Reactors

Plant	Cover gas system		
	Gas pressure (at operation) (MPa)		Other systems
	Primary	Secondary	
Rapsodie (France)	0.002	0.03	-
KNK-II (Germany)	0.002	0.45	0.0001
FBTR (India)	sl.ab.atm.*	sl.ab.atm.*	sl.ab.atm.*
PEC (Italy)	0.002 (0.06**) gauge	0.005 gauge	0.004 gauge
JOYO (Japan)	0.001	0.02	0.005
DFR (UK)	0.025	0.035	-
BOR-60 (Russian Federation)	0.049	0.049	sl.ab.atm.*
EBR-II (USA)	sl.ab.atm.*	0.0414	sl.bel. atm.*
Fermi (USA)	0.1	0.13-0.29	0.1
FFTF (USA)	0.003 gauge	0.61 gauge	0.002 gauge
BR-10 (Russian Federation)	0.03 gauge	0.03 gauge	-
CEFR (China)	0.05	0.2	sl.ab.atm.*

#### Demonstration or Prototype Fast Reactors

Phénix (France)	sl.ab.atm.*	sl.ab.atm.*	sl.ab.atm.*
SNR-300 (Germany)	0.152	-	0.469
PFBR (India)	0.111 ±0.001	0.4 ±0.05	sl.ab.atm.*
MONJU (Japan)	0.05	0.1	sl.ab.atm.*
PFR (UK)	sl.ab.atm.*	sl.ab.atm.*	sl.ab.atm.*
CRBRP (USA)	0.105	0.117 abs.	sl.ab.atm.*
BN-350 (Kazakhstan)	0.186 abs.	0.245 abs.	sl.ab.atm.*
BN-600 (Russian Federation)	0.137 abs.	0.245	sl.ab.atm.*
ALMR (USA)	-	0.128	sl.ab.atm.*
KALIMER-150 (Republic of Korea)	0.1913	not yet decided	
SVBR-75/100 (Russian Federation)	0.11	no secondary circuits	-
BREST-OD-300 (Russian Federation)	sl.ab.atm.*	no secondary circuits	sl.ab.atm.*

\* slightly above atmosphere or slightly below atmosphere

\*\* test channel

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Commercial Size Reactors

Plant	Cover gas system		
	Gas pressure (at operation) (MPa)		Other systems
	Primary	Secondary	
Super-Phénix 1 (France)	0.007-0.011*	0.13-0.16*	0.025-0.0025*
Super-Phénix 2 (France)	sl.ab.atm.*	sl.ab.atm.*	-
SNR 2 (Germany)	sl.ab.atm.*	-	-
DFBR (Japan)	0.09	0.15	sl.ab.atm.*
CDFR (UK)	sl.ab.atm.*	sl.ab.atm.*	-
BN-1600 (Russian Federation)	0.137 abs.	0.245 abs.	sl.ab.atm.*
BN-800 (Russian Federation)	0.149 abs.	0.245 abs.	sl.ab.atm.*
EFR	0.105-0.123	0.22-0.25	sl.ab/bel.atm.*
ALMR (USA)	-	0.128	al.ab.atm.*
SVBR-75/100 (Russian Federation)	0.11	no secondary circuits	-
BN-1800 (Russian Federation)	0.245	0.245	not yet decided
BREST-1200 (Russian Federation)	sl.ab.atm.*	no secondary circuits	al.ab.atm.*
JSFR-1500 (Japan)	0.17	0.3	sl.ab.atm.*

\* slightly above atmosphere or slightly below atmosphere

## 8. AUXILIARY SYSTEMS (cont.)

8.2.

Cover gas system

### Experimental Fast Reactors

Plant	Cover gas system		
	Method of gas sampling		
	Primary	Secondary	Other systems
Rapsodie (France)	on-line	-	-
KNK-II (Germany)	-	-	-
FBTR (India)	flow through	sampler	-
PEC (Italy)	on-line	none	-
JOYO (Japan)	capsule pot	cylindrical pot	cylindrical pot
DFR (UK)	buffer tanks with interlocks	-	-
BOR-60 (Russian Federation)	periodic on-line sampling	-	-
EBR-II (USA)	grab sample	grab sample	-
Fermi (USA)	-	-	-
FFTF (USA)	on-line	grab sample	on-line
BR-10 (Russian Federation)	grab sample	grab sample	-
CEFR (China)	on-line	grab sample	grab sample

### Demonstration or Prototype Fast Reactors

Phénix (France)	on-line	-	-
SNR-300 (Germany)	-	-	-
PFBR (India)	on-line	-	-
MONJU (Japan)	on-line and off - line monitoring	-	-
PFR (UK)	on-line and discrete sampling	-	-
CRBRP (USA)	on-line	grab sample	on-line
BN-350 (Kazakhstan)	periodic on-line sampling	-	-
BN-600 (Russian Federation)	periodic on-line sampling	-	-
ALMR (USA)	grab sample	grab sample	grab sample
KALIMER-150 (Republic of Korea)	on-line	not yet decided	-
SVBR-75/100 (Russian Federation)	on-line	no secondary circuits	-
BREST-OD-300 (Russian Federation)	periodoc on-line sampling	no secondary circuits	-

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Commercial Size Reactors

Plant	Cover gas system		
	Method of gas sampling		
	Primary	Secondary	Other systems
Super-Phénix 1 (France)	on-line	periodic discrete sampling on-line (fuel transfer)	
Super-Phénix 2 (France)	on-line	-	-
SNR 2 (Germany)	-	-	-
DFBR (Japan)	-	-	-
CDFR (UK)	periodic discrete sampling	periodic discrete sampling	not determined
BN-1600 (Russian Federation)	periodic on-line sampling		-
BN-800 (Russian Federation)	on-line sampling		not determined
EFR	periodic on-line sampling		not determined
ALMR (USA)	grab sample	grab sample	grab sample
SVBR-75/100 (Russian Federation)	on-line	no secondary circuits	-
BN-1800 (Russian Federation)	on-line sampling		not yet decided
BREST-1200 (Russian Federation)	periodic on-line sampling	no secondary circuits	-
SFR-1500 (Japan)	to be determined	to be determined	to be determined

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Experimental Fast Reactors

	Cover gas system
Plant	Method of gas analysis (primary)
Rapsodie (France)	mass spectrometry, gas chromatography
KNK-II (Germany)	-
FBTR (India)	mass spectrometry, gas chromatography
PEC (Italy)	gas chromatography, ionization chamber
JOYO (Japan)	gas chromatography
DFR (UK)	-
BOR-60 (Russian Federation)	gas chromatography
EBR-II (USA)	thermal conductivity, flame emission, Ge-Li gamma scan; mass spectrometry
Fermi (USA)	-
FFTF (USA)	gas chromatography
BR-10 (Russian Federation)	gamma spectrometry
CEFR (USA)	gas chromatograph, gamma spectrometry

#### Demonstration or Prototype Fast Reactors

Phénix (France)	mass spectrometry, gas chromatography, ionization chamber
SNR-300 (Germany)	gas chromatography
PFBR (India)	gas chromatography, ionization chamber, gamma spectrometry
MONJU (Japan)	-
PFR (UK)	gas chromatography, gamma spectrometry, mass spectrometry
CRBRP (USA)	gas chromatography
BN-350 (Kazakhstan)	gas chromatography, ionization chamber
BN-600 (Russian Federation)	gas chromatography, ionization chamber
ALMR (USA)	mass spectrometry, gas chromatography
KALIMER-150 (Republic of Korea)	gas chromatography
SVBR-75/100 (Russian Federation)	gas chromatography, ionization chamber
BREST-OD-300 (Russian Federation)	gas chromatography, measure O <sub>2</sub> , H <sub>2</sub> , H <sub>2</sub> O vapor and radio-activity

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Commercial Size Reactors

	Cover gas system
Plant	Method of gas analysis (primary)
Super-Phénix 1 (France)	gas chromatography, ionization chamber, gamma spectrometry
Super-Phénix 2 (France)	not determined
SNR 2 (Germany)	not determined
DFBR (Japan)	not determined
CDFR (UK)	not determined
BN-1600 (Russian Federation)	gas chromatography
BN-800 (Russian Federation)	gas chromatography
EFR	gas chromatography
ALMR (USA)	mass spectrometry, gas chromatography, hydrocarbon analysis
SVBR-75/100 (Russian Federation)	gas chromatography, ionization chamber
BN-1800 (Russian Federation)	not yet decided
BREST-1200 (Russian Federation)	gas chromatography, measure O <sub>2</sub> , H <sub>2</sub> , H <sub>2</sub> O vapor and radio-activity
JSFR-1500 (Japan)	to be determined

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Experimental Fast Reactors

Plant	Cover gas system	
	Secondary	Method of gas analysis Other systems
Rapsodie (France)	-	-
KNK-II (Germany)	-	-
FBTR (India)	mass spectrometry and gas chromatography	-
PEC (Italy)	-	-
JOYO (Japan)	gas chromatography	gas chromatography
DFR (UK)	-	-
BOR-60 (Russian Federation)	gas chromatography	-
EBR-II (USA)	thermal conductivity, H <sub>2</sub> -diffusion meter	-
Fermi (USA)	gas chromatography	measure O <sub>2</sub> , H <sub>2</sub> , and radioactivity
FFTF (USA)	-	-
BR-10 (Russian Federation)	measure O <sub>2</sub>	-
CEFR (China)	gas chromatography	gamma spectrometry

#### Demonstration or Prototype Fast Reactors

Phénix (France)	-	measure O <sub>2</sub> , H <sub>2</sub> O vapour, and radioactivity
SNR-300 (Germany)	gas chromatography	-
PFBR (India)	-	-
MONJU (Japan)	-	-
PFR (UK)	-	-
CRBRP (USA)	gas chromatography	measure O <sub>2</sub> , H <sub>2</sub> O vapor, and radioactivity
BN-350 (Kazakhstan)	gas chromatography	-
BN-600 (Russian Federation)	gas chromatography	-
ALMR (USA)	gas chromatography and mass spectrometry	-
KALIMER-150 (Republic of Korea)	gas chromatography	not yet decided
SVBR-75/100 (Russian Federation)	no secondary circuits	-
BREST-OD-300 (Russian Federation)	no secondary circuits	measure O <sub>2</sub> , H <sub>2</sub> , H <sub>2</sub> O vapor, and radioactivity

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Commercial Size Reactors

Plant	Cover gas system	
	Method of gas analysis	
	Secondary	Other systems
Super-Phénix 1 (France)	none	gas chromatography, measure O <sub>2</sub> , H <sub>2</sub> O and radioactivity
Super-Phénix 2 (France)	not determined	-
SNR 2 (Germany)	not determined	-
DFBR (Japan)	not determined	-
CDFR (UK)	not determined	not determined
BN-1600 (Russian Federation)	gas chromatography	-
BN-800 (Russian Federation)	gas chromatography	-
EFR	gas chromatography	not determined
ALMR (USA)	gas chromatography and mass spectrometry	-
SVBR-75/100 (Russian Federation)	no secondary circuits	-
BN-1800 (Russian Federation)	not yet decided	
BREST-1200 (Russian Federation)	no secondary circuits	gas chromatography, measure O <sub>2</sub> , H <sub>2</sub> , H <sub>2</sub> O vapor and radioactivity
JSFR-1500 (Japan)	to be determined	to be determined

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Experimental Fast Reactors

	Cover gas system
Plant	Cover gas clean-up system (principle)
Rapsodie (France)	active carbon filter before discharge
KNK-II (Germany)	active carbon filter
FBTR (India)	filtration before discharge
PEC (Italy)	carbon delay bed and cryogenic column
JOYO (Japan)	cryogenic activated charcoal bed
DFR (UK)	vapour traps
BOR-60 (Russian Federation)	aerosol filters
EBR-II (USA)	cryo distillation
Fermi (USA)	vapour trap, cyclone separator
FFTF (USA)	carbon delay bed and cold trap
BR-10 (Russian Federation)	no gas clean-up system
CEFR (China)	aerosol filters and active carbon bed

#### Demonstration or Prototype Fast Reactors

Phénix (France)	active carbon bed and cryogenic effect
SNR-300 (Germany)	active carbon filter
PFBR (India)	dynamic absorption into activated charcoal bed at cryogenic temperature
MONJU (Japan)	charcoal delay bed
PFR (UK)	aerosol and absolute filters
CRBRP (USA)	cryogenic still
BN-350 (Kazakhstan)	aerosol filters
BN-600 (Russian Federation)	aerosol filters
ALMR (USA)	activated carbon bed
KALIMER-150 (Republic of Korea)	not yet decided
SVBR-75/100 (Russian Federation)	aerosol filters, vapor steam condenser
BREST-OD-300 (Russian Federation)	aerosol, oxygen and hydrogen filters

## 8. AUXILIARY SYSTEMS (cont.)

### 8.2. Cover gas system

#### Commercial Size Reactors

	Cover gas system
Plant	Cover gas clean-up system (principle)
Super-Phénix 1 (France)	active carbon bed and cryogenic effect
Super-Phénix 2 (France)	sweeping and filtering
SNR 2 (Germany)	not determined
DFBR (Japan)	mist/vapour trap
CDFR (UK)	not determined
BN-1600 (Russian Federation)	aerosol filters
BN-800 (Russian Federation)	aerosol filters
EFR	aerosol filters and activated carbon bed
ALMR (USA)	activated carbon bed
SVBR-75/100 (Russian Federation)	aerosol filters, vapor steam condenser
BN-1800 (Russian Federation)	aerosol filters
BREST-1200 (Russian Federation)	aerosol, oxygen and hydrogen filters
JSFR-1500 (Japan)	mist/vapour trap and filtering

## 8. AUXILIARY SYSTEMS (cont.)

### 8.3. Decay heat removal system

#### Experimental Fast Reactors

Plant	Decay heat removal system Type
Rapsodie (France)	NCM
KNK-II (Germany)	NCM
FBTR (India)	NCM
PEC (Italy)	ES
JOYO (Japan)	PM
DFR (UK)	TS
BOR-60 (Russian Federation)	NCM, TS
EBR-II (USA)	ES
Fermi (USA)	NCM, PM
FFTF (USA)	NCM
BR-10 (Russian Federation)	NCM and forced flow (battery)
CEFR (China)	NCM, TS

#### Demonstration or Prototype Fast Reactors

Phénix (France)	PM, RV
SNR-300 (Germany)	NCM
PFBR (India)	ES, PM, TS
MONJU (Japan)	ES, PM
PFR (UK)	PM, TS
CRBRP (USA)	PM, NCM, ES
BN-350 (Kazakhstan)	PM
BN-600 (Russian Federation)	NCM, PM
ALMR (USA)	RV
KALIMER-150 (Republic of Korea)	RV
SVBR-75/100 (Russian Federation)	NCM, RV
BREST-OD-300 (Russian Federation)	NCM, PM, TS

- NCM - removal of decay heat by natural convection, through main coolant loops
- ES - removal of decay heat through special heat removal loops to air (forced flow)
- PM - removal of decay heat through main coolant loops by pony motors
- TS - removal of decay heat through thermal syphon loops to air (natural convection only)
- RV - removal of heat through reactor vessel by radiation and convection

## 8. AUXILIARY SYSTEMS (cont.)

### 8.3. Decay heat removal system

#### Commercial Size Reactors

Plant	Decay heat removal system
	Type
Super-Phénix 1 (France)	ES,PM,TS,RV
Super-Phénix 2 (France)	ES,TS
SNR 2 (Germany)	-
DFBR (Japan)	ES,PM
CDFR (UK)	PM,NCM, ES,TS
BN-600 (Russian Federation)	PM,TS
BN-800 (Russian Federation)	NCM,PM,ES and TS
EFR	NCM,PM,ES and TS
ALMR (USA)	RV
SVBR-75/100 (Russian Federation)	NCM, RV
BN-1800 (Russian Federation)	not yet decided
BREST-1200 (Russian Federation)	NCM, PM, TS
JSFR-1500 (Japan)	NCM (1DRACS+2PRACS)

- NCM - removal of decay heat by natural convection, through main coolant loops
- ES - removal of decay heat through special heat removal loops to air (forced flow)
- PM - removal of decay heat through main coolant loops by pony motors
- TS - removal of decay heat through thermal syphon loops to air (natural convection only)
- RV - removal of heat through reactor vessel by radiation and convection

## 8. AUXILIARY SYSTEMS (cont.)

### 8.3. Decay heat removal systems

#### Experimental Fast Reactors

Plant	Decay heat removal systems	
	Capacity for emergency removal of decay heat (MWth)	Delay before operation in an emergency situation(s)
Rapsodie (France)	0.35	1800
KNK-II (Germany)	-	-
FBTR (India)	0.35	600
PEC (Italy)	capable of handling 5% of nominal power (not defined*)	in continuance operation (not defined*)
JOYO (Japan)	2.6	simultaneous with reactor scram
DFR (UK)	2.2	0
BOR-60 (Russian Federation)	-	15
EBR-II (USA)	0.35	on-line continuously
Fermi (USA)	30	-
FFTF (USA)	capable of handling 8% of rated power	< 60
BR-10 (Russian Federation)	battery 108 A. h, 220 V	0.2
CEFR (China)	0.525x2	< 60

#### Demonstration or Prototype Fast Reactors

Phénix (France)	12	1800
SNR-300 (Germany)	12	-
PFBR (India)	4x8	1800
MONJU (Japan)	45	simultaneous with reactor scram
PFR (UK)	15	120
CRBRP (USA)	PM: 100, ES-1: 18, ES-2: 45, ES-3: 10, NCM: not available	automatic
BN-350 (Kazakhstan)	30	15
BN-600 (Russian Federation)	45	15
ALMR (USA)	1.8***	0
KALIMER-150 (Republic of Korea)	2.6	0
SVBR-75/100 (Russian Federation)	1.5	100 h
BREST-OD-300 (Russian Federation)	3.5	on-line continuously in hot reserve

\* test channel

\*\*\* 5.7 MW (th) peak at 21 hours

## 8. AUXILIARY SYSTEMS (cont.)

### 8.3. Decay heat removal systems

#### Commercial Size Reactors

Plant	Decay heat removal systems	
	Capacity for emergency removal of decay heat (MWth)	Delay before operation in an emergency situation (s)
Super-Phénix 1 (France)	48 + 15	~ 1800
Super-Phénix 2 (France)	~ 100	~ 1800
SNR 2 (Germany)	-	-
DFBR (Japan)	14	-
CDFR (UK)	80	60
BN-1600 (Russian Federation)	120 (PM), 110**(TS)	15 (PM) 60 (TS)
BN-800 (Russian Federation)	80	60
EFR	90	0 to 1800
ALMR (USA)	1.8***	0
SVBR-75/100 (Russian Federation)	1.5	100 h
BN-1800 (Russian Federation)	80	not yet decided
BREST-1200 (Russian Federation)	to be decided	on-line continuously in hot reserve
JSFR-1500 (Japan)	23 in each heat exchanger	simultaneous with reactor scram

\*\* for loops, 27.5 MWth each

\*\*\* 5.7 MW (th) peak at 21 hours

## 8. AUXILIARY SYSTEMS (cont.)

### 8.4. Preheating system

#### Experimental Fast Reactors

	Preheating system
Plant	Primary circuit(s)
Rapsodie (France)	hot nitrogen
KNK-II (Germany)	-
FBTR (India)	hot nitrogen
PEC (Italy)	electrical resistance trace heating elements
JOYO (Japan)	hot nitrogen and electric trace heating
DFR (UK)	space and trace heating
BOR-60 (Russian Federation)	hot gas and electrical heating
Fermi (USA)	induction and resistance
FFTF (USA)	electrical resistance trace heating elements
BR-10 (Russian Federation)	hot gas and electrical heating
CEFR (China)	hot nitrogen and electrical heating

#### Demonstration or Prototype Fast Reactors

Phénix (France)	hot nitrogen and electrical resistance
SNR-300 (Germany)	hot nitrogen and trace heating
PFBR (India)	hot nitrogen
MONJU (Japan)	electric trace heating
PFR (UK)	hot argon
CRBRP (USA)	electrical resistance
BN-350 (Kazakhstan)	hot gas and electrical heating
BN-600 (Russian Federation)	hot gas and electrical heating
ALMR (USA)	hot gas
KALIMER-150 (Republic of Korea)	to be decided
SVBR-75/100 (Russian Federation)	saturated steam
BREST-OD-300 (Russian Federation)	hot air

## 8. AUXILIARY SYSTEMS (cont.)

### 8.4. Preheating system

#### Commercial Size Reactors

	Preheating system
Plant	Primary circuit(s)
Super-Phénix 1 (France)	hot nitrogen*
Super-Phénix 2 (France)	hot nitrogen
SNR 2 (Germany)	not decided
DFBR (Japan)	hot gas
CDFR (UK)	to be determined
BN-1600 (Russian Federation)	hot gas and electrical heating
BN-800 (Russian Federation)	hot gas and electrical heating
EFR	hot nitrogen
ALMR (USA)	hot gas
SVBR-75/100 (Russian Federation)	saturated steam
BN-1800 (Russian Federation)	electrical heating
BREST-1200 (Russian Federation)	hot air
JSFR-1500 (Japan)	to be determined

\* for initial sodium filling

## 8. AUXILIARY SYSTEMS (cont.)

### 8.4. Preheating system

#### Experimental Fast Reactors

	Preheating system
Plant	Secondary circuit(s)
Rapsodie (France)	electrical heating
KNK-II (Germany)	-
FBTR (India)	electrical heating
PEC (Italy)	electrical resistance trace heating
JOYO (Japan)	electrical trace heating
DFR (UK)	space and trace heating
BOR-60 (Russian Federation)	electrical heating
EBR-II (USA)	induction resistance
Fermi (USA)	induction and resistance
FFTF (USA)	electrical resistance trace heating
BR-10 (Russian Federation)	electrical heating
CEFR (China)	hot nitrogen and electrical heating

#### Demonstration or Prototype Fast Reactors

Phénix (France)	electrical heating
SNR-300 (Germany)	-
PFBR (India)	electrical trace heating
MONJU (Japan)	electric trace heating
PFR (UK)	trace heating
CRBRP (USA)	electrical resistance
BN-350 (Kazakhstan)	electrical heating
BN-600 (Russian Federation)	electrical heating
ALMR (USA)	not decided
KALIMER-150 (Republic of Korea)	to be decided
SVBR-75/100 (Russian Federation)	no secondary circuit
BREST-OD-300 (Russian Federation)	no secondary circuit

## 8. AUXILIARY SYSTEMS (cont.)

### 8.4. Preheating system

#### Commercial Size Reactors

Plant	Preheating system
	Secondary circuit(s)
Super-Phénix 1 (France)	electrical heating
Super-Phénix 2 (France)	electrical heating
SNR 2 (Germany)	not determined
DFBR (Japan)	electrical heating
CDFR (UK)	to be determined
BN-1600 (Russian Federation)	electrical heating
BN-800 (Russian Federation)	electrical heating
EFR	electrical heating
ALMR (USA)	electrical heating
SVBR-75/100 (Russian Federation)	no secondary circuit
BN-1800 (Russian Federation)	electrical heating
BREST-1200 (Russian Federation)	no secondary circuit
JSFR-1500 (Japan)	to be determined

## 8. AUXILIARY SYSTEMS (cont.)

### 8.4. Preheating system

#### Experimental Fast Reactors

Plant	Preheating system	
	Preheating temperature (°C)	
	Primary	Secondary
Rapsodie (France)	250	-
KNK-II (Germany)	200	-
FBTR (India)	150	150
PEC (Italy)	200	200
JOYO (Japan)	150-230	150-230
DFR (UK)	-	-
BOR-60 (Russian Federation)	250	250
EBR-II (USA)	305	-
Fermi (USA)	200	200
FFTF (USA)	316	204
BR-10 (Russian Federation)	200	200
CEFR (China)	200-250	200-250

#### Demonstration or Prototype Fast Reactors

Phénix (France)	150	200
SNR-300 (Germany)	200	-
PFBR (India)	150	150
MONJU (Japan)	200	200
PFR (UK)	200	200
CRBRP (USA)	204	-
BN-350 (Kazakhstan)	250	250
BN-600 (Russian Federation)	200	250
ALMR (USA)	200	200
KALIMER-150 (Republic of Korea)	150-200	to be decided
SVBR-75/100 (Russian Federation)	180	no secondary circuit
BREST-OD-300 (Russian Federation)	420-470	no secondary circuit

## 8. AUXILIARY SYSTEMS (cont.)

### 8.4. Preheating system

#### Commercial Size Reactors

Plant	Preheating system	
	Preheating temperature (°C)	
	Primary	Secondary
Super-Phénix 1 (France)	150	180
Super-Phénix 2 (France)	230	-
SNR 2 (Germany)	not determined	-
DFBR (Japan)	150-250	150-250
CDFR (UK)	not determined	-
BN-1600 (Russian Federation)	200	250
BN-800 (Russian Federation)	200	250
EFR	150	230
ALMR (USA)	200	200
SVBR-75/100 (Russian Federation)	180	no secondary circuit
BN-1800 (Russian Federation)	electrical heating	-
BREST-1200 (Russian Federation)	420-470	no secondary circuit
JSFR-1500 (Japan)	to be determined	to be determined