5. CONTROL RODS AND DRIVE MECHANISMS

5.1. Safety (shutdown) rods[(a)]
5.2. Regulating rods[(b)]
5.3. Rapid shutdown rods[(c)]
5.4. Additional shutdown rods[(d)]

Experimental Fast Reactors

Plant	Safety (shutdown) rods[(a)]	Regulating rods[(b)]		Rapid shutdown rods[(c)]	Additional shutdown rods[(d)]
		No. of group 1 regulating rods, sometimes designated "fine rods"	No. of group 2 regulating rods, sometimes designated "coarse rods"		
Rapsodie (France)	6	6	5	6	-
KNK-II (Germany)	8	-	-	-	-
FBTR (India)	6	6	0	-	-
PEC (Italy)	-	11	-	11	-
JOYO (Japan)	none (4 in MK-1)	6 (2 in MK-1)	none	6 (4 in MK-1)	none
DFR (UK)	9	0	6	15	-
BOR-60 (Russian Federation)	3	2	2	-	-
EBR-II (USA)	2	-	-	-	-
Fermi (USA)	8	2	-	-	-
FFTF (USA)	9	3	6	-	-
BR-10 (Russian Federation)	2 MRR*	2 (Ni)	1 MRR	2	-
CEFR (China)	3	2	3	8	-

Demonstration or Prototype Fast Reactors

Phénix (France)	6 (safety and regulating)	-	-	-	-
SNR-300 (Germany)	12	1	8	-	-
PFBR (India)	3	9	-	-	-
MONJU (Japan)	6	3	10	-	-
PFR (UK)	5	0	5	10	-
CRBRP (USA)	15	9	6	-	-
BN-350 (Kazakhstan)	3	2	7	5	-
BN-600 (Russian Federation)	6	2	19	8	-
ALMR (USA)	-	9	-	-	6GEM**+ 3 USS***
KALIMER-150 (Republic of Korea)	1 USS	-	-	-	6 GEM
SVBR-75/100 (Russian Federation)	6	2	29	13	
BREST-OD-300 (Russian Federation)	8	12	8	-	45 HSR**** +12 GEM

* MRR movable ring reflector (Ni)
** GEM gas expansion module
*** The ultimate shutdown system (USS) injects B_4C balls (see 5.9.11)
**** HSR - hydraulically suspended rod

Safety (shutdown) rods[(a)] - No. of safety (shut down) rods
Regulating rods[(b)] - No. of regulating rods (or combined regulating and safety rods)
Rapid shutdown rods[(c)] - No. of rods contributing to rapid shutdown within the first and second shutdown systems
Additional shutdown rods[(d)] - No. of additional, diverse, shutdown rods or devices

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.1. Safety (shutdown) rods[(a)]
5.2. Regulating rods[(b)]
5.3. Rapid shutdown rods[(c)]
5.4. Additional shutdown rods[(d)]

Commercial Size Reactors

Plant	Safety (shutdown) rods[(a)]	Regulating rods[(b)]		Rapid shutdown rods[(c)]	Additional shutdown rods[(d)]
		No. of group1 regulating rods, sometimes designated "fine rods	No. of group 2 regulating rods, sometimes designated "coarse rods"		
Super-Phénix 1 (France)	24	21	-	21	3
Super-Phénix 2 (France)	27	-	-	-	-
SNR 2 (Germany)	25 + 12 (articulated)	-	-	-	-
DFBR (Japan)	30	-	-	-	-
CDFR (UK)	12	0	18	-	-
BN-1600 (Russian Federation)	12	2	23	37	-
BN-800 (Russian Federation)	12	2	16	12	3 HSRs****
EFR*****	33	5+12	4+12	33	-
ALMR (USA)	-	9	-	-	6 GEM** + 3 ultimate system injects ***
SVBR-75/100(Russian Federation)	6	2	29	13	-
BN-1800 (Russian Federation)	18	2	17	18	5 HSRs
BREST-1200 (Russian Federation)	to be determined				
JSFR-1500 (Japan)	-	-	-	-	-
Breeding core	17	-	40******	-	-
Break even core	17	-	40******	-	-

** GEM - gas expansion module
*** the ultimate system injects B_4C balls
**** HSR - hydraulically suspended rod
***** diverse shutdown rods + control and shutdown rods
****** group 1 and 2 rods

Safety (shutdown) rods[(a)] - No. of safety (shut down) rods
Regulating rods[(b)] - No. of regulating rods (or combined regulating and safety rods)
Rapid shutdown rods[(c)] - No. of rods contributing to rapid shutdown within the first and second shutdown systems
Additional shutdown rods[(d)] - No. of additional, diverse, shutdown rods or devices

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.5. Absorber pins

Experimental Fast Reactors

	Absorber pins		
	No. of absorber pins per control rod		
Plant	Safety rods	Group 1 rods	Group 2 rods
Rapsodie (France)	1	-	-
KNK-II (Germany)	55	-	55
FBTR (India)	1	-	-
PEC (Italy)	7	7	7
JOYO (Japan)	none (7 in MK-I)	7	none (17.6 in MK-I)
DFR (UK)	1		10*
BOR-60 (Russian Federation)	7	4	7
EBR-II (USA)	-	-	-
Fermi (USA)	6	19	-
FFTF (USA)	-	61	61
BR-10 (Russian Federation)	-	-	-
CEFR (China)	7	7	7

Demonstration or Prototype Fast Reactors

Phénix (France)	7	-	-
SNR-300 (Germany)	19	19	19
PFBR (India)	19	19	-
MONJU (Japan)	19	19	19
PFR (UK)	19	-	19
CRBRP (USA)	-	37	31
BN-350 (Kazakhstan)	7	7	85
BN-600 (Russian Federation)	7	31	8
ALMR (USA)	-	61	-
KALIMER-150 (Republic of Korea)	-	61	-
SVBR-75/100 (Russian Federation)	1	7	7
BREST-OD-300 (Russian Federation)	30	30	-

* fuel pins

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.5. Absorber pins

Commercial Size Reactors

	Absorber pins		
	No. of absorber pins per control rod		
Plant	Safety rods	Group 1 rods	Group 2 rods
Super-Phénix 1 (France)	31/16***	31	-
Super-Phénix 2 (France)	20 or 31	-	-
SNR 2 (Germany)	55 (articulated)	61	-
DFBR (Japan)	31	-	-
CDFR (UK)	19	-	19
BN-1600 (Russian Federation)	not determined		
BN-800 (Russian Federation)	7	7	7
EFR	37/55**	37/55**	37/55**
ALMR (USA)	-	61	
SVBR-75/100 (Russian Federation)	1	7	7
BN-1800 (Russian Federation)	19	19	19
BREST-1200 (Russian Federation)	to be determined		
JSFR-1500 (Japan)	-	-	-
Breeding core	19	19	19
Break even core	19	19	19

** control and shutdown rods/diverse shutdown rods
*** diverse shutdown rods

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.5. Absorber pins

Experimental Fast Reactors

Plant	Absorber pins		
	Outer diameter of absorber pin safety (mm)	Group 1	Group 2
Rapsodie (France)	45.0	-	-
KNK-II (Germany)	10.3	10.3	-
FBTR (India)	-	-	-
PEC (Italy)	17.7	17.7	17.7
JOYO (Japan)	none*	18.5**	none
DFR (UK)	23.0	-	20.0***
BOR-60 (Russian Federation)	12.0	12.0	12.0
EBR-II (USA)	-	-	-
Fermi (USA)	15.9	7.9	-
FFTF (USA)	12.0	12.0	-
BR-10 (Russian Federation)	-	-	-
CEFR (China)	14.9	14.9	14.9

Demonstration or Prototype Fast Reactors

Phénix (France)	28.0	-	-
SNR-300 (Germany)	15.5	15.5	15.5
PFBR (India)	21.4	22.4	-
MONJU (Japan)	17.0	17.0	17.0
PFR (UK)	22.0	-	22.0
CRBRP (USA)	-	15.3	14.0
BN-350 (Kazakhstan)	23.0	9.5	6.9
BN-600 (Russian Federation)	23.0	9.5	23.0
ALMR (USA)	-	16.7	-
KALIMER-150 (Republic of Korea)	to be determined		
SVBR-75/100 (Russian Federation)	40.0	12.0	12.0
BREST-OD-300 (Russian Federation)	20.5	20.5	-

* MK-III; (17.6 in MK-I)

** MK-III; (17.8 and 18.5 in MK-I and MK-II, respectively)

*** the reactor was controlled by movement of fuel pins in triangular clusters

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.5. Absorber pins

Commercial Size Reactors

Plant	Absorber pins		
	Outer diameter of absorber pin safety (mm)	Group 1	Group 2
Super-Phénix 1 (France)	21/53, 26.7****	21.0	-
Super-Phénix 2 (France)	-	-	-
SNR 2 (Germany)	-	17.6	-
DFBR (Japan)	20.0	-	-
CDFR (UK)	22.0	-	22.0
BN-1600 (Russian Federation)	not determined	-	-
BN-800 (Russian Federation)	23.0	23.0	23.0
EFR	22.78/16.35*****	22.78/16.35*****	22.78/16.35*****
ALMR (USA)	-	16.7	
SVBR-75/100 (Russian Federation)	40.0	12.0	12.0
BN-1800 (Russian Federation)	31.0	31.0	31.0
BREST-1200 (Russian Federation)	to be determined		
JSFR-1500 (Japan)	-	-	-
Breeding core	34.8	35.8	35.8
Break even core	34.8	35.8	35.8

**** diverse shutdown rods

*****control and shutdown rods / diverse shutdown rods

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.5. Absorber pins

Experimental Fast Reactors

Plant	Absorber pins		
	Material of neutron absorber (safety)	Group 1	Group 2
Rapsodie (France)	BC90	BC90	-
KNK-II (Germany)	-	BC93	-
FBTR (India)	BC90	BC90	-
PEC (Italy)	-	BC90	-
JOYO (Japan)	none (BC90 in MK-1)	BC90	none
DFR (UK)	B80	fuel	-
BOR-60 (Russian Federation)	BC80	BC80 or Eu_2O_3	BC80
EBR-II (USA)	fuel	fuel + BC followers	-
Fermi (USA)	BC	BC	-
FFTF (USA)	B20	B20	B20
BR-10 (Russian Federation)*	-	-	-
CEFR (China)	BC91	BC20	BC91

Demonstration or Prototype Fast Reactors

Phénix (France)	BC48	BC48	BC48
SNR-300 (Germany)	BC47	BC47	BC47
PFBR (India)	BC65	BC65	-
MONJU (Japan)	BC90	BC39	BC39
PFR (UK)	BC40	BC20	BC20
CRBRP (USA)	BC92	BC92	BC92
BN-350 (Kazakhstan)	BC80	BC60	UO_2enriched/UO_2 depleted
BN-600 (Russian Federation)	BC80	BC20	BC20
ALMR (USA)	-	BC92	-
KALIMER-150 (Republic of Korea)	BC	BC	-
SVBR-75/100 (Russian Federation)	BC50	BC50	BC50
BREST-OD-300 (Russian Federation)	BC20	Er_2O_3	-

* movable ring reflector (Ni)

[If B_4C is used it is abbreviated below as BCx, where x is the enrichment (%B^{10}) and if boron powder or sintered powder is used it is abbreviated as Bx]

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.5. Absorber pins

Commercial Size Reacotrs

Plant	Absorber pins		
	Material of neutron absorber (safety)	Group 1	Group 2
Super-Phénix 1 (France)	BC90	BC90	-
Super-Phénix 2 (France)	BC90	BC90	BC90
SNR 2 (Germnay)	-	B90	B90
DFBR (Japan)	BC92	-	-
CDFR (UK)	BC30	-	BC20
BN-1600 (Russian Federation)	BC80	BC80	BC80
BN-800 (Russian Federation)	BC92	BC20	BC60
EFR	BC30, 45, 90	BC30,45,90	BC30, 90**
ALMR (USA)	-	BC20	-
SVBR-75/100 (Russian Federation)	BC50	BC50	BC50
BN-1800 (Russian Federation)	BC92	-	-
BREST-1200 (Russian Federation)	to be determined		
JSFR-1500 (Japan)	-	-	-
Breeding core	BC80	BC80	BC80
Break even core	BC80	BC80	BC80

** control and shutdown rods/diverse shutdown rods

[If B_4C is used it is abbreviated below as BCx, where x is the enrichment ($\%B^{10}$) and if boron powder or sintered powder is used it is abbreviated as Bx]

5.CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.6. Worth of control rod

Experimental Fast Reactors

Plant	Worth of control rod (% ΔK/K)				
	Safety (total)	Group 1 (total)	Group 1 (per rod)	Group 2 (total)	Total reactivity worth of all rods moving over whole range
Rapsodie (France)	10.0	-	-	15.0	-
KNK-II (Germany)	4.5	-	-	-	-
FBTR (India)	6.92	-	-	-	-
PEC (Italy)	6.8	-	-	-	6.8
JOYO (Japan)	none	10.1 (13 in MK-II)	1.9 in row 3, 0.7-r. 5	none	10.1 (13 in MK-II)
DFR (UK)	8.0	-	-	8.0	-
BOR-60 (Russian Federation)	4.15	0.8	0.4	3.2	-
EBR-II (USA)	1.0 B_{ef}	3.7 B_{ef}	0.8 B_{ef}*	-	-
Fermi (USA)	9.2 B_{ef}	0.92	-	-	-
FFTF (USA)	-	6.3	8.4	-	-
BR-10 (Russian Federation)	5.1	0.18	0.09	5.1	5.1
CEFR (China)	3.09	0.30	0.15	1.82	9.03

Demonstration or Prototype Fast Reactors

Phénix (France)	8.0	-	-	-	-
SNR-300 (Germany)	2.9	7.3	0.8	-	-
PFBR (India)	4.0	10.1	1.1	-	14.5
MONJU (Japan)	5.8	-	-	-	7.0**
PFR (UK)	2.0	-	-	7.0	-
CRBRP (USA)	-	22.2 B_{ef}	12.8 B_{ef}	-	-
BN-350 (Kazakhstan)	3.5	0.5	0.25	3.2	-
BN-600 (Russian Federation)	2.9	0.48	0.24	7.0	-
ALMR (USA)	9.3	-	-	-	-
KALIMER-150 (Republic of Korea)	2.1	8.2	-	-	-
SVBR-75/100 (Russian Federation)	1.37	0.48	0.27	6.0	6.48
BREST-OD-300 (Russian Federation)	0.72	0.70 (per rod)	0.15 (per GEM)	0.26 (per HSR)	3.6

* with boron follower (0.38 B_{ef} -without boron follower)

** group 1 and 2 with one rod stuck

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.6. Worth of control rod

Commercial Size Reactors

Plant	Worth of control rod (% ΔK/K)				
	Safety (total)	Group 1 (total)	Group 1 (per rod)	Group 2 (total)	Total reactivity worth of all rods moving over whole range
Super-Phénix 1 (France)	10.0	8.5	0.4	-	10.0
Super-Phénix 2 (France)	12.0	-	-	-	-
SNR 2 (Germany)	2.9	8.5	0.4	-	-
DFBR (Japan)	8.9 + 1.6	-	-	-	-
CDFR (UK)	4.0	-	-	5.0	-
BN-1600 (Russian Federation)	2.8	0.4	0.2	6.7	-
BN-800 (Russian Federation)	4.1	0.4	0.2	6.1	9.0
EFR***	10.3	8.1	0.34	-	10.3
ALMR (USA)	6.8	-	-	-	-
SVBR-75/100 (Russian Federation)	1.37	0.48	0.27	6.0	6.48
BN-1800 (Russian Federation)	to be determined				
BREST-1200 (Russian Federation)	to be determined				
JSFR-1500 (Japan)	-	-	-	-	-
Breeding core	2.3	-	-	-	6.8****
Break even core	to be determined				

*** diverse shutdown

**** group 1 and 2 with one rod stuck

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.7. Vertical travel of control rod

Experimental Fast Reactors

	Vertical travel of control rod (mm)		
Plant	Safety	Group 2	Group 1
Rapsodie (France)	450	-	-
KNK-II (Germany)	670	-	620
FBTR (India)	450	-	450
PEC (Italy)	750	750	750
JOYO (Japan)	none*	none*	650*
DFR (UK)	700	600	-
BOR-60 (Russian Federation)	450	450	400
EBR-II (USA)	361	361	361
Fermi (USA)	1370	-	508
FFTF (USA)	940	940	940
BR-10 (Russian Federation)	300-340	300-340	280
CEFR (China)	500±20	500±20	500±20

Demonstration or Prototype Fast Reactors

Phénix (France)	900	-	-
SNR-300 (Germany)	1050	-	830
PFBR (India)	1075	-	1085
MONJU (Japan)	1100	1000	1000
PFR (UK)	1320	1070	-
CRBRP (USA)	914-960	952	-
BN-350 (Kazakhstan)	1260	1060	750
BN-600 (Russian Federation)	900	900	750
ALMR (USA)	914	***	-
KALIMER-150 (Republic of Korea)	to be determined		
SVBR-75/100 (Russian Federation)	1200	1000	1000
BREST-OD-300 (Russian Federation)	870	870	1300

* MK-III; [900, 700 (fine and coarse) 5.7.1 and 5.7.3, respectively, MK-I]

*** by B_4C ball injection system

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.7. Vertical travel of control rod

Commercial Size Reactors

	Vertical travel of control rod (mm)		
Plant	Safety	Group 2	Group 1
Super-Phénix 1 (France)	1100	-	1100
Super-Phénix 2 (France)	1250	1250	1250
SNR-2 (Germany)	1200	1200	1200
DFBR (Japan)	1000	-	-
CDFR (UK)	1150	1000	-
BN-1600 (Russian Federation)	900	900	900
BN-800 (Russian Federation)	1030	870	870
EFR	1000/945**	1000/945**	1000/945**
ALMR (USA)	to be determined		
SVBR-75/100 (Russian Federation)	1200	1000	1000
BN-1800 (Russian Federation)	to be determined		
BREST-1200 (Russian Federation)	to be determined		
JSFR-1500 (Japan)	-	-	-
Breeding core	1000	1000	1000
Break even core	1000	1000	1000

** control and shutdown rods/diverse shutdown rods

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.8. Rod-drop time

Experimental Fast Reactors

	Rod-drop time, designed (seconds)		
Plant	Safety	Group 2	Group 1
Rapsodie (France)	0.4	-	-
KNK-II (Germany)	0.3	-	-
FBTR (India)	0.4	-	0.4
PEC (Italy)	0.5	0.5	0.5
JOYO (Japan)	none (0.8 in MK-1)	none	0.8
DFR (UK)	0.4	0.35	-
BOR-60 (Russian Federation)	0.5	200	-
EBR-II (USA)	1.0	0.450	-
Fermi (USA)	0.9	-	46
FFTF (USA)	0.935	0.935	-
BR-10 (Russian Federation)	0.4	0.4	-
CEFR (China)	0.7	2.5	2.5

Demonstration or Prototype Fast Reactors

Phénix (France)	0.7	-	-
SNR-300 (Germany)	0.55	0.56	0.56
PFBR (India)	1.0	-	1.0
MONJU (Japan)	less than 1.2	less than 1.2	less than 1.2
PFR (UK)	0.5	0.45	-
CRBRP (USA)	-	1.0	1.8
BN-350 (Kazakhstan)	0.7	220	5
BN-600 (Russian Federation)	1.0	160	11
ALMR (USA)	1.0	120	-
KALIMER-150 (Republic of Korea)	to be determined		
SVBR-75/100 (Russian Federation)	1.0	3.0	3.0
BREST-OD-300 (Russian Federation)	less than 2.5	less than 2.5	6.0 (per HSR*)

* HSR - hydraulically suspended rod

5.CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.8. Rod-drop time

Commercial Size Reactors

	Rod-drop time, designed (seconds)		
Plant	Safety	Group 2	Group 1
Super-Phénix 1 (France)	0.8	-	0.8
Super-Phénix 2 (France)	1.0	1.0	1.0
SNR 2 (Germany)	0.8	0.8	-
DFBR (Japan)	less than 1.2	-	-
CDFR (UK)	1.0	0.8	-
BN-1600 (Russian Federation)	to be determined		
BN-800 (Russian Federation)	1.0	174	13.0
EFR	0.7/0.7*	0.7/0.7*	0.7/0.7*
ALMR (USA)	1.0	120	-
SVBR-75/100 (Russian Federation)	1.0	3.0	3.0
BN-1800 (Russian Federation)	to be determined		
BREST-1200 (Russian Federation)	to be determined		
JSFR-1500 (Japan)	0.8	0.8	0.8

* control and shutdown rods/diverse shutdown rods

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.9. Features of drive mechanism

Experimental Fast Reactors

	Features of drive mechanism
Plant	Safety
Rapsodie (France)	screw drive with magnetic hold-up
KNK-II (Germany)	-
FBTR (India)	screw drive with magnetic hold-up
PEC (Italy)	electro-magnetic
JOYO (Japan)	none*
DFR (UK)	screw drive gear with magnetic hold-up
BOR-60 (Russian Federation)	gravity and spring assist
EBR-II (USA)	safety rods are pulled out of core by heavy yoke at bottom, uponmanual release
Fermi (USA)	-
FFTF (USA)	electro-mechanical linear actuating
BR-10 (Russian Federation)	gravity
CEFR (China)	ball-screw drive gear with magnetic hold-up, spring acceleration

Demonstration or Prototype Fast Reactors

Phénix (France)	mechanical + electro-mechanical
SNR-300 (Germany)	screw drive gear with magnetic hold-up (1st), springacceleration (2nd)
PFBR (India)	electro-mechanical in hot pool holds head of rod
MONJU (Japan)	motor drive/spring acceleration
PFR (UK)	screw drive gear with magnetic hold-up
CRBRP (USA)	primary: collapsible roller-nut drive; spring assisted gravity insertion
BN-350 (Kazakhstan)	rack drive gear with magnetic hold-up
BN-600 (Russian Federation)	rack drive gear with magnetic hold-up and accelerating spring
ALMR (USA)	B_4C balls released into open thimble at core center
KALIMER-150 (Republic of Korea)	SASS**, Curie point magnets
SVBR-75/100 (Russian Federation)	rack drive gear with electromagnetic hold-up, accelerating spring and visible lock
BREST-OD-300 (Russian Federation)	electro-mechanical

* motor drive/spring accleration in MK-1

** SASS – self-actuated shutdown system

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.9. Features of drive mechanism

Commercial Size Reactors

	Features of drive mechanism
Plant	Safety
Super-Phénix 1 (France)	rack drive gear with magnetic hold-up/electro magnet in sodium*
Super-Phénix 2 (France)	mechanical + electro-mechanical
SNR 2 (Germany)	1) electro-magnet in gas; 2) electro-magnet in sodium
DFBR (Japan)	screw drive gear with magnetic hold-up and SASS**
CDFR (UK)	screw drive gear with magnetic hold-up
BN-1600 (Russian Federation)	rack drive gear with magnetic hold-up and accelerating spring
BN-800 (Russian Federation)	rack drive gear with magnetic hold-up and accelerating spring
EFR	1) electro magnet in gas; 2) electro magnet in sodium
ALMR (USA)	B_4C balls released into open thimble at core centre
SVBR-75/100 (Russian Federation)	rack drive gear with electromagnetic hold-up, accelerating spring and visible lock
BN-1800 (Russian Federation)	to be determined
BREST-1200 (Russian Federation)	electro-mechanical
JSFR-1500 (Japan)	screw drive gear with magnetic hold-up and SASS**

* diverse shutdown rods

** SSAS - a passive shutdown system (Curie point magnets)

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.9. Features of drive mechanism

Experimental Fast Reactors

	Features of drive mechanism	
Plant	Coarse	Fine
Rapsodie (France)	-	-
KNK-II (Germany)	falling	-
FBTR (India)	-	-
PEC (Italy)	electro-magnetic	electro-magnetic
JOYO (Japan)	none*	motor drive / spring acceleration
DFR (UK)	screw drive gear with magnetic hold up	-
BOR-60 (Russian Federation)	screw drive gear with magnetic hold up	-
EBR-II (USA)	control rods actuated manually or automatically use air-assist and dashpot system to optimize velocity of stroke	-
Fermi (USA)	-	ball-nut-and-screw
FFTF (USA)	electro-mechanical linear actuating	electro-mechanical linear actuating
BR-10 (Russian Federation)	electro-mechanical	electro-mechanical
CEFR (China)	ball-screw and magnetic	ball-screw and magnetic

Demonstration or Prototype Fast Reactors

Phénix (France)	mechanical and electro-mechanical	-
SNR-300 (Germany)	screw drive gear with magnetic hold up	-
PFBR (India)	mechanical gripper holds head of rod; EM at inter seal argon atmosphere holds mobile assembly	-
MONJU (Japan)	motor drive/gas pressure acceleration (for both)	-
PFR (UK)	screw drive gear with magnetic hold up	-
CRBRP (USA)	secondary: ball-nut screw drive; hydraulic assisted insertion; coarse (fixed shim rods): none	-
BN-350 (Kazakhstan)	screw drive gear	screw drive gear
BN-600 (Russian Federation)	rack drive gear	rack drive gear
ALMR (USA)	ball-nut screw drive; motor-assisted drive in; fine motion control	-
KALIMER-150 (Republic of Korea)	ball-nut screw drive; motor-assisted drive in; fine motion control	-
SVBR-75/100 (Russian Federation)	rack drive gear with electro-magnetic hold-up, accelerating spring and visible lock	-
BREST-OD-300 (Russian Federation)	electro-mechanical	-

* MK-III. Motor drive / spring acceleration in MK-I

5. CONTROL RODS AND DRIVE MECHANISMS (cont.)

5.9. Features of drive mechanism

Commercial Size Reactors

	Features of drive mechanism	
Plant	Coarse	Fine
Super-Phénix 1 (France)	rack drive gear with magnetic hold up	-
Super-Phénix 2 (France)	mechanical and electro-mechanical	-
SNR 2 (Germany)	screw drive gear with magnetic hold up	-
DFBR (Japan)	-	-
CDFR (UK)	screw drive gear with magnetic hold up	-
BN-1600 (Russian Federation)	rack drive gear	rack drive gear
BN-800 (Russian Federation)	rack drive gear	rack drive gear
EFR	mechanical and electro-mechanical	mechanical and electro-mechanical
ALMR (USA)	ball-nut screw drive; motor assisted drive in, fine motion control	-
SVBR-75/100 (Russian Federation)	rack drive gear with electromagnetic hold-up, accelerating spring and visible lock	-
BN-1800 (Russian Federation)	to be determined	-
BREST-1200 (Russian Federation)	electro-mechanical	-
JSFR-1500 (Japan)	screw drive gear with magnetic hold up	-