
Contents

ABBREVIATIONS	9
1. VR-1 REACTOR	11
2. NEUTRON DETECTION AND NEUTRON FLUX DISTRIBUTION MEASUREMENT	17
2.1 Introduction	17
2.2 Basic Principles of Neutron Detection	17
2.3 Gas-filled Neutron Detectors	18
2.4 Classification of Gas-filled Neutron Detectors	21
2.5 Detectors Used in Measurement at VR-1 Reactor	23
2.6 Characteristics of Gas Neutron Detectors	23
2.7 Measurement of Characteristics of Gas Neutron Detectors	24
2.8 Determination of Relative Thermal Neutron Distribution	27
2.9 Dead Time of Detection Systems	29
2.10 Tasks and Questions	31
2.11 Safety Notes	32
2.12 Related Reading	32
3. DELAYED NEUTRON DETECTION	33
3.1 Introduction	33
3.2 Prompt and Delayed Neutrons Generation	33
3.3 Delayed Neutron Groups and Their Properties	35
3.4 Influence of Delayed Neutrons on the Reactor Dynamics	37
3.5 Determination of Delayed Neutrons Properties	40
3.6 Determination of Uranium Content Using Delayed Neutron Counting	43
3.7 Limits of Detection	45
3.8 Tasks and Questions	46
3.9 Related Reading	46
4. REACTOR KINETICS STUDY	47

4.1	Introduction	47
4.2	Zero Power Reactor without Delayed Neutrons	47
4.3	Point Kinetics Theory with Delayed Neutrons	49
4.4	Study of Reactor Kinetics at the VR-1 Reactor	55
4.5	Safety Notes	62
4.6	Tasks and Questions	62
4.7	Related Reading	63
5.	REACTOR DYNAMICS STUDY	65
5.1	Reactivity Feedback and Reactor Dynamics	65
5.2	Study of Reactor Dynamics at the VR-1 Reactor	68
5.3	Safety Notes	70
5.4	Tasks and Questions	70
5.5	Related Reading	70
6.	REACTIVITY MEASUREMENT	71
6.1	Introduction	71
6.2	Reactivity Definition	72
6.3	Rod Drop and Source Jerk Methods	73
6.4	Positive Period Method	76
6.5	Source-Multiplication Method	78
6.6	Reactimeter	83
6.7	Tasks and Questions	84
6.8	Related Reading	84
7.	CONTROL ROD CALIBRATION	85
7.1	Introduction	85
7.2	Types of Control Rods	85
7.3	Integral and Differential Control Rod Worth	85
7.4	Control Rod Calibration by Inverse Rate Method	87
7.5	Dynamic Determination of Control Rod Worth	89

7.6	Mutual Control Rod Calibration	90
7.7	Tasks and Questions	91
7.8	Related Reading	91
8.	CRITICAL EXPERIMENT – APPROACHING THE CRITICAL STATE	93
8.1	Introduction	93
8.2	Theory	93
8.3	Approaching the Critical State at the VR-1 Reactor	95
8.4	Safety Notes	96
8.5	Tasks and Questions	97
8.6	Related Reading	97
9.	DIGITAL SAFETY AND CONTROL SYSTEM OF THE VR-1 REACTOR	99
9.1	Introduction	99
9.2	Reactor I&C Basics	99
9.3	VR-1 Reactor I&C Structure	102
9.4	Safety Features of I&C	103
9.5	I&C Safety Classification	104
9.6	Reactor I&C Components	105
9.7	Related Reading	113
10.	START-UP AND OPERATION OF THE VR-1 REACTOR	115
10.1	Introduction	115
10.2	Reactor Regimes and Modes	115
10.3	Safety and Warning Signals	116
10.4	Use of HMI for Reactor Control	118
10.5	Start-up of the Reactor	124
10.6	Demonstration of Reactor Utilization	126
11.	RADIATION PROTECTION AT THE REACTOR	129
11.1	Introduction	129
11.2	Quantities and Limits in Radiation Protection	129

11.3	Radiation Protection at the VR-1 Reactor	131
11.4	Radiation Monitoring During Reactor Operation	131
11.5	Measurement of Surface Activity and Surface Decontamination	132
11.6	Tasks and Questions	132
11.7	Related Reading	132
12.	REFERENCES	133
APPENDIX 1.	EMK310 EQUIPMENT FOR NEUTRON MEASUREMENT	135
APPENDIX 2.	LCM310 - LOW CURRENT MONITOR	139
APPENDIX 3.	DEVICE FOR DYNAMICS STUDY	143
	Vertical Oscillator	143
	Rotary Oscillator	148
APPENDIX 4.	DEVICE FOR BUBBLE BOILING SIMULATION	151
APPENDIX 5.	INSTRUMENTATION FOR TEMPERATURE REACTIVITY EFFECTS	155
APPENDIX 6.	BOKIN USER GUIDE	157
	Common Instructions	157
	Sample Tasks	159